NEPTUNE'S TABLE

A View of America's Ocean Fisheries

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NEPTUNE'S TABLE

A View of America's Ocean Fisheries

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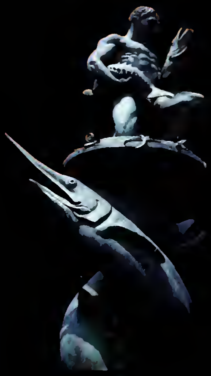
Director of Photography
William B. Folsom



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June 2002

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Cover photograph: William B. Folsom, NOAA Fisheries

The depicted sculpture is by Ana Hyatt Huntington, donated by the artist in 1962 to the City of New Bedford, Massachusetts and may be seen at the New Bedford, Massachusetts, Waterfront Visitors Center.

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FOREWORD

Neptune's Table is about America's bountiful fisheries resources and the Americans who fish for them. It stands as homage to past generations who have fed the nation from these riches, and tribute to the countless individuals today who are determined to preserve them. It honors those who have struggled to make a living under grueling, dangerous conditions, and others who have lost their lives in that struggle. The book depicts the rise and, sometimes, the fall of businesses that harvest marine stocks. And it exposes the mystery and beauty known to those who gather up the great gifts off America's shores.

This is not the usual kind of document produced by the National Marine Fisheries Service. Charged with stewardship of the nation's living marine resources, the agency each year produces hundreds of reports, regulations, advisories, and other papers necessary to conserve and manage these stocks. There have been excellent historic accounts—most of them technical—about individual fisheries and the industry's development. And more recently, many people and organizations have written of the need to safeguard fish stocks and their environment.

Over the years, we have come to recognize that fish are not limitless and can be depleted. We also realize that healthy fisheries depend on healthy coastal habitat. Now we are seeing the rise of a conservation ethic and public willingness to take the steps necessary to restore populations and their habitat. Although commercial and recreational fisheries enterprises are annually worth billions of dollars to the nation's economy, this is a relatively small sector of our national economy. On the other hand, the U.S. fishing industry employs hundreds of thousands of our citizens, produces the world's finest and most varied seafood, generates sportfishing opportunities, and adds immeasurably to America's quality of life. It falls to the National Marine Fisheries Service and coastal state, regional, and tribal fisheries management agencies to ensure these remarkable benefits continue for future generations of Americans.

Neptune's Table serves a distinct purpose from the other offerings of this agency and its parent organization, the National Oceanic and Atmospheric Administration. It provides the American public with a snapshot of the nation's fisheries as we move into the next millennium, to tell them who fishes and how, what their problems are, and how they are solving them. This book reflects our belief that here, as in other areas of tradition, we can only know where we are going if we know where we have been.

Penelope D. Dalton
1999–2001 Assistant Administrator
for Fisheries
National Oceanic and
Atmospheric Administration

ACKNOWLEDGMENTS

This book could not have been produced without the contributions and assistance of many individuals and organizations. The author is especially grateful for the support and encouragement of NOAA officials Penelope Dalton, William Hogarth, Rolland Schmitten, Andrew Kemmerer, Andrew Rosenberg, and the late Nancy Foster.

Special thanks are also extended to NOAA Fisheries staff throughout the country who provided information and reviewed the text: the Science Centers and Regional Offices; General Counsel; and offices of Operations, Management and Information; Science and Technology; Habitat Conservation; Protected Resources; Sustainable Fisheries; Industry and Trade; and Intergovernmental and Recreational Fisheries. The agency's Seafood Inspection Program and Office of Law Enforcement were especially helpful in arranging photographic shoots of their operations. Contracted advisers who provided direction and scope for the book were James Loveless, Clarence Pautzke, and Brad Warren. The editing, graphics, design and layout, and fishing gear illustration were provided through contracts to The Communications Collective of Bethesda, Maryland.

Gratitude is also extended to the many businesses and state and territorial agencies that made their facilities and personnel available for the project and provided valuable information on local fisheries. Special thanks go to Bumble Bee Tuna of Mayagüez, Puerto Rico, especially Javier Colley; to Tallmadge Brothers, Inc., Oysters and Clams of Norwalk, Connecticut; to Atlantic Littleneck Clams Farms of James Island, South Carolina; to W.H. Harris Seafood, Inc., of Kent Island, Maryland; and to Anthony's Restaurant, sponsor of Seattle's Oyster Olympics. For extensive field assistance in Texas, thanks go to Elizabeth P. Walker, of Padre Island; Penn Camera and Positive Images, of Tyson's Corner, Virginia, provided valuable photographic guidance; and Sutton Place Gourmet, of McLean, Virginia, assisted generously with food photography.

The work of many fine photographers appears here. In particular, NOAA Fisheries expresses its gratitude to William Folsom, Lauri Lawson, Nance Trueworthy, Karen Ducey, Edward Pastula, Charles Ess, Allen Shimada, and Dennis Weidner for prodigious photographic contributions. Historic photographs were made available by the National Fishing Institute, *National Fisherman* and *Pacific Fishing* magazines, and the Columbia River Intertribal Fish Commission. NOAA's Central Library and the National Sea Grant Program Office were invaluable in locating source material—most *Neptune's Table* images, as well as thousands of others taken during this project, are now archived in the Central Library for use by the public. Willis Hobard, of the NOAA Fisheries Scientific Publications Unit, and C. Eugene Cope were also most helpful in locating photographic resources.

Finally, the author, the director of photography, and NOAA Fisheries are deeply indebted to the hundreds of Americans who took time from their commercial and recreational fishing activities to assist in the development of this book. To them, and to all who enjoy the generous bounty of *Neptune's Table*, this book is dedicated.

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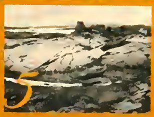

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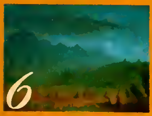

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John Singleton Copley
Detail from *Watson and the Shark*
Ferdinand Lammot Belin Fund
Photograph 1998 © Board of Trustees,
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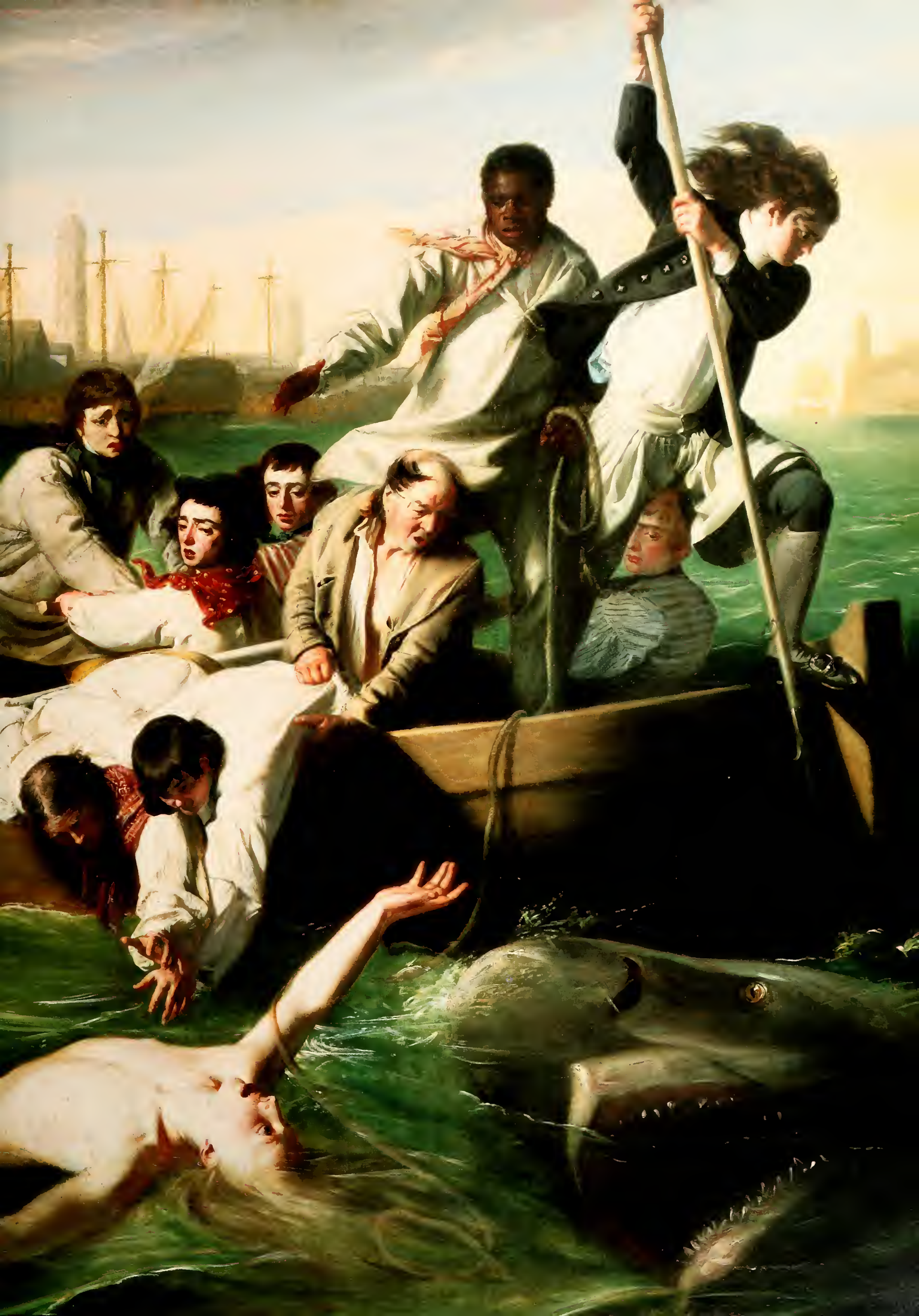
INTRODUCTION



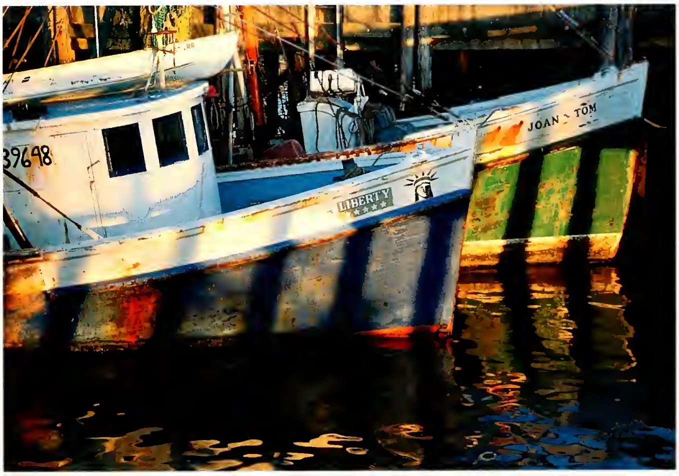
In Greek mythology, the god Poseidon ruled the ocean, but this deity is perhaps better known as the Roman god Neptune. Occasionally, both exacted tribute in the form of shipwrecks and drownings. Neptune is the emblem of this book, a symbol of both the sea's bounty and the American spirit that brings those resources to the nation's table. *Neptune's Table* views fisheries resources through that lens.

THIS BOOK'S INTENT

This book is different from other books about the sea. In 1971, the National Marine Fisheries Service marked 100 years of federal involvement in fisheries with its publication of *Our Changing Fisheries.* That book was a compilation of 44 papers that described the life history, status, and use of American fisheries resources up to 1970. It also included a futuristic view that called for steps to maintain and utilize fisheries resources in the face of an ever-increasing demand for fish products.

In hindsight, *Our Changing Fisheries* was perhaps somewhat naive, anticipating that science alone could resolve whatever fisheries problems the nation might encounter. Nevertheless, it contained kernels of remarkable vision. The authors foresaw the great potential for aquaculture and what were then called "latent" (undeveloped) fisheries. They anticipated sophisticated technologies that would

Roman ruins in Morocco show the importance of fishing to the empire's coastal town. © *William B. Folsom Photography, Inc.*



The fishing boat—symbol of an entire industrial sector. © *Nance S. Trueworthy*

FACING PAGE: Elegance. © *William B. Folsom Photography, Inc.*

San Francisco is one of hundreds of American communities with both commercial and recreational fishing fleets. © *Allen M. Shimada*

permit scientists to better understand harvest limits and the effects of growing environmental degradation. And they astutely predicted the ensuing overexploitation of fisheries resources.

At the time *Our Changing Fisheries* was written, there was already interest in extending national sovereignty over marine resources. America's answer, under the powerful leadership of Washington's Senator Warren Magnuson, was to eliminate foreign fishing fleets from national waters in favor of domestic fleets in U.S. waters, thereby claiming the abundant fish stocks for the nation's own wealth.

The 1976 Fishery Conservation and Management Act, which was named for Senator Magnuson in 1980, achieved that goal. Since 1989, foreign catch in American territorial waters has been minor, while the catch of U.S. fishermen has more than doubled. And although the Act contained the necessary ingredients for fisheries' sustainability, it had an unanticipated effect: domestic overfishing replaced foreign overfishing.

Since the Act was first passed, fisheries managers have been faced not only with rapid increases in the nation's capacity to harvest fish, but also with the needs of various species—fish and nonfish alike—that require special handling or outright protection under the Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973. These laws, and the overarching National Environmental Policy Act, reflected the strong public commitment to the conservation of dolphins, whales, seals, sea turtles, and certain fish (especially salmon). Together, they compel fisheries managers to broaden their thinking, to take a more holistic ecosystems approach.

The explosive growth of recreational fishing since 1976 has added to the complexity of fisheries management. No longer are conflicts primarily between different commercial fleets, as when fish traps become ensnared in trawl nets. Hostilities between sectors today often polarize entire coastal towns into opposing camps seeking a larger share of the seafood pie, with some citizens supporting commercial interests and others championing recreational fishing. And all the pie eaters, collectively, are sometimes gobbled up by coastal development that threatens nearshore fish habitat and facilities needed by fishermen, such as docks and processing plants.

By the Act's 20th anniversary, the "long view" of sustainability had begun to prevail and, with it, a call for stringent measures to ensure healthy fisheries. The Magnuson–Stevens Fishery Conservation and Management Act, renamed for the fisheries conservation efforts of Alaska's Senator Ted Stevens, is the most comprehensive—and conservation-oriented—of several reauthorizations of the Act improving federal fisheries regulation and management. It forces federal fisheries managers to take into account the protection of marine ecosystems when providing for optimum yield from the nation's fisheries.

Neptune's Table looks at the nation's fisheries over that period of great change (1970–2000). It is not a technical discussion of fisheries science and management, or a detailed look at fish species. Rather, it presents a snapshot of America's commercial and recreational ocean fisheries—who fishes, how they do it, how they feel about their work, their contributions to the nation's well-being, and what problems fisheries face. Not all fisheries are given the same attention, but both offshore and nearshore units are represented,

TOP: Visitors to Valdez, Alaska, are often surprised by the number of fishing vessels. © *William B. Folsom Photography, Inc.* **LEFT:** A man and his son visiting from Ohio try their luck at bridge fishing near Charleston, South Carolina. *William B. Folsom, NOAA Fisheries.* **RIGHT:** Alaska's midnight sun graces the North Pacific ecosystem but sometimes makes fishing difficult. © *Allen M. Shimada*

regardless of whether they're managed by federal or state government agencies.

THE GROWTH OF AMERICAN FISHERIES

Through much of history, the growth of a nation's fisheries depended on an abundance of nearshore fish and shellfish. America has been especially fortunate in this wealth, and since its founding has shipped great quantities of its fish resources abroad. But the expansion of sea power for merchant and military fleets also contributed to growth in fishing. By the 1960s, America was among the developed nations exerting enormous fishing effort virtually everywhere on earth.

When the U.S. Fish Commission was established in 1871, the most important American fishing center was New England, although almost every coastal town had at least one fishery. Early

A re-enactment at Virginia's Sky Meadows State Park celebrates America's love of seafood. © *William B. Folsom Photography, Inc./ David M. Santmyer*

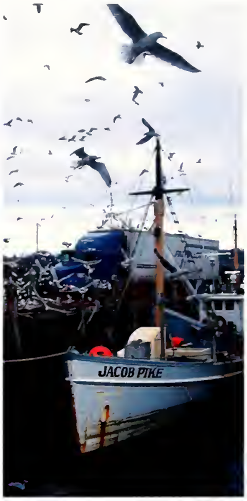
restaurants and homes regularly served oyster, herring, snapper, eel, shrimp, sturgeon caviar, Dungeness crab, and salmon. Seafood was even to be had in the Midwest, although it was mostly prepared from dried or salted fish. (Large-scale distribution of fresh seafood was hampered by small-scale harvesting methods and by lack of ice, cold-storage facilities, and rapid transit.)

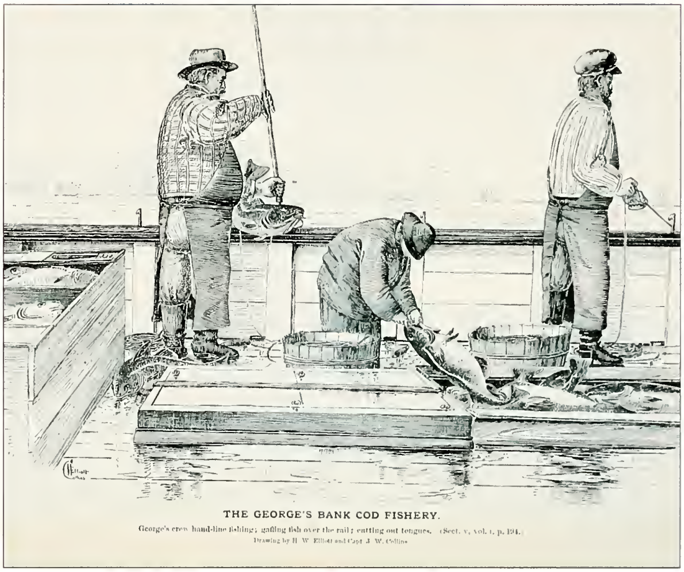
Until the 20th century, the world's fishing fleets consisted mainly of small sailing or rowed boats fishing in nearshore waters. The main distant-water fleets were for whaling and tuna. But the country's fishery potential was huge and developed rapidly, especially after World War II. The early 1900s saw the widespread use of gasoline-powered engines, and by the 1930s, conversion to diesel power. At the same time, vessels were increasing in size and design to allow fishing in ever more distant waters. Great Britain launched the first factory trawler in 1954, and soon many nations took enormous hauls of herring, haddock, halibut, and salmon in the territorial waters of other countries.

The Magnuson Act resulted in explosive growth of the U.S. fisheries fleet. The great uncertainty associated with fishing makes determining the exact number of full-time fishermen and fishing vessels difficult. People move in and out of the occupation as market prices for fish fluctuate, vessel costs (fuel, insurance, etc.) rise, and personal and family circumstances change. Overfishing and degraded habitats resulting in closed waters have thrown many fishermen out of work, and new management regimes have sometimes consolidated financial interests. Also, a vessel owner may register several vessels, but may only fish one or two of them at a time, and it's sometimes years before managers become aware that boats have changed names, have sunk, or have been relegated to the scrap yard. The best estimates suggest that there are about 80,000 commercial fishing craft in America.

The seafood processing sector, including wholesalers and distributors, is also quite fluid as firms enter and leave the industry. According to government estimates, almost 4,800 seafood processing and wholesaling plants were operating in 1995, employing more than 85,000 workers. The number of employees, however, tends to fluctuate with the seasonal availability of local products and imports from other regions and nations.

Horse-towed seines for salmon were a common sight in late 19th-century Puget Sound. *National Archives, courtesy of Scientific Publications Unit, NOAA Fisheries.* **INSET:** The 19th-century schooner gave way to this century's much larger vessels, including giant factory ships. © *Allen M. Shimada*




THE GEORGE'S BANK COD FISHERY.
George's crew hand-line fishing; gaffing fish over the rail; cutting out tongues. (Sect. v, vol. i, p. 194.)
Drawing by H. W. Elliott and Capt. J. W. Collins

ABOVE LEFT: A dock in Port Aransas, Texas, mirrors the thousands in the country that berth the massive U.S. recreational fleet. *William B. Folsom, NOAA Fisheries.* **ABOVE RIGHT:** Gulls above a Gloucester, Massachusetts, fishing boat don't always mean success—the catch may not be profitable. © *Nance S. Trueworthy.* **RIGHT:** A 19th-century engraving shows a Georges Bank crew handlining for cod, a species now badly overfished. *Drawings by H.W. Elliott and Captain J.W. Collins. The Fisheries and Fishery Industries of the United States, NOAA Fisheries*

TODAY'S ISSUES

The phenomenal growth of the fishing industry was not without a toll. In common with other resource exploitation industries, U.S. fisheries face serious problems. Some of these—domestic overfishing, competition, and bycatch—are of their own doing, but others are beyond the control of individual fishermen: foreign overfishing of shared stocks, habitat degradation, and global market competition.

Overfishing

Although some important stocks are seriously depleted, American fisheries have remained remarkably productive overall. There are two ways of determining the health and productivity of fisheries stocks: compare their status relative to the level that would produce a sustainable long-term yield ("status of the stock"), and assess the degree to which the resource has been harvested ("status of utilization"). In the case of stock status for the major U.S. fisheries resources (about 201 inshore and offshore stocks), the best estimate at the time of this writing is that about 30 percent are below their long-term potential—that is, more or larger fish would come from the combined effects of rebuilding overfished stocks, reducing bycatch, and reducing excess capital. Another 27 percent of the stocks are near their potential now, producing about as much as they probably ever can. And about 9 percent could stand more fishing pressure. But for the remaining stocks—about 34 percent—there isn't enough scientific information to determine their status.

When one looks at the utilization of these resources, however, the picture is slightly different: about 23 percent of American fisheries stocks are overutilized, 34 percent are fully utilized, and 12 percent are underutilized; for 31 percent, their status is unknown. Together with the status of the stocks, utilization information can be used to determine measures that will help a fishery reach its maximum potential. It is important to understand, however, that many—perhaps most—of the nation's underutilized fisheries stocks are resources with a low market demand and value, such as skates. Conversely, highly valued stocks, such as bluefin tuna and cod, are those most likely to be overfished. The point here is that although some valuable species are considered overfished, many fisheries, especially those in waters off Alaska, remain potent and viable contributors to America's wealth.

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MINH-PHUNG

TOP: A newly renamed trawler reflects the role of immigration in the development of American fisheries. *William B. Folsom, NOAA Fisheries.*
INSET: A commercial fisherman voices his views on proposed management measures at a public hearing. *Lauri Lawson, NOAA Fisheries.*
BOTTOM: As in ports everywhere, most of the New Bedford fleet operates under moratoriums against new vessels. *William B. Folsom, NOAA Fisheries.*

The public seems to be of two minds about its fisheries. On one hand, the citizenry hears from media experts about the urgent need for greater conservation of the stocks. On the other, the great variety of seafood available to consumers makes it difficult to believe there are serious problems in U.S. fisheries.

Limited Access

Until very recently, American fishermen have tended to believe that everyone is entitled to fish for any resource. The outcome of such "open access" is now evident in many fisheries: lower yields, declining stocks, "derbies" where fishermen race to catch scarce resources, shortened fishing seasons, excess capacity to harvest and process fish, unsafe fishing conditions, volatile prices and landings patterns, excessive bycatch, and lower product quality. For many fisheries, traditional management regimes—such as regulations defining allowable gear types, fishing areas, fishing seasons, and total catch—haven't succeeded in achieving economic sustainability.

This type of management has sometimes stabilized or reversed stock declines, but fisheries may still be unhealthy in the sense that the same level of harvest could be achieved at a lower overall cost. For this and other reasons, managers are turning to restricted-access regimes, primarily in the form of moratoria to prevent new entrants. Most U.S. fisheries and a large number of fisheries elsewhere in the world have gone farther, with individual fishing quotas that give only historic participants a "right" to fish. In some innovative quota programs—individual transferable quotas (ITQs) and individual fish quotas (IFQs)—a fisherman's quota may be sold, leased, bequeathed, inherited, used as loan collateral, or not used at all.

However, a great many American fishermen see individual quotas as infringing on an inherent "right to fish" and prefer unmanaged competition as the adjudicator of economic survival. Many fishermen view ITQs negatively, as limiting their own options to fish for new resources, curtailing incentives to work hard, and restricting their children's opportunities in the family fishing tradition. (Much of this opposition comes from relatively new fishery entrants with no history of catches, who would probably get few, if any, shares of a quota-bound resource.) Many fishermen also fear the corporatism inherent in ITQs. But increasingly, economic and social information revealing that the true costs, value, and benefits of fishing may well support calls for expanded limited access in U.S. fisheries.

Bycatch

Another issue, bycatch, is a magnet for public concern on several accounts: stock depletion, wasted resources, harm to marine mammals and other protected resources, and ecosystem damage. Controversy is especially likely when one fishery inadvertently catches fish that constitute another group's livelihood, or when vessel owners are required to purchase new, more selective gear in order to protect dolphins, sea turtles, and seabirds. Bycatch can have sweeping consequences, leading to policies that change how fisheries operate. For example, public reaction to dolphin kills in tuna purse seines led most of the U.S. Pacific tuna fleet to relocate from California across the Pacific to Guam and America Samoa, where dolphins aren't generally taken in tuna nets.

Competition

Conflict among resource users is another headline-level problem. The remarkable growth of recreational fishing in the United States has led to a schism between it and the commercial sector, with each group engaging in hardball lobbying for the greater slice of the shared-resource pie. But there have always been conflicts among various sectors of the commercial industry itself. Quarrels erupt between fishermen using different gear for the same or different stocks, among fishermen of neighboring states fishing for the

SAY NO TO DRUGS
DON'T EAT FARMED FISH

A Seward, Alaska, salmon boat makes clear its owner's view on competition from salmon farms. © *William B. Folsom Photography, Inc.*

The trapping of seals and other animals in lost fishing gear has sometimes inflamed public sentiment against fishermen. *Zoe Lucas, NOAA Fisheries*

same resources, between tribal and nontribal fishing interests competing for salmon, and between U.S. fishermen and other nations fishing for tuna and other shared international stocks.

Competition and conflict are indeed part and parcel of capitalist commerce, and they are nowhere more evident than in America's fisheries. There are frequent, hot disputes over "owned" fishing sites, preferred docking spots, and undercutting market prices. An occasional skipper is accused of poaching, "stealing" crew members, deliberately damaging or even stealing gear, deliberately taking heavy bycatches that can later be discarded—dead—if better fish show up, or other unsavory practices. And not the least of their troubles, commercial fishermen must struggle against a flood of lower-priced seafood imports that often surpass the quality of domestic products. American fishermen themselves often see imports as unwelcome competition, but importing can also legitimately be claimed as giving a "breather" to some overfished domestic stocks and stabilizing markets, permitting the restaurant industry to flourish and consumers to try new products.

The fishing industry in many regions must also contend with the increasing displacement of the shoreside facilities they depend on. Vessels are being evicted from their customary dockage by newer developments with greater income or tax benefits, and moved farther away from buyers and easy ocean access. Shoreside processing plants, vessels, and even seafood markets encounter objections from nearby condominiums and restaurants concerning the pungent odors, industrial sounds, and seagull fouling.

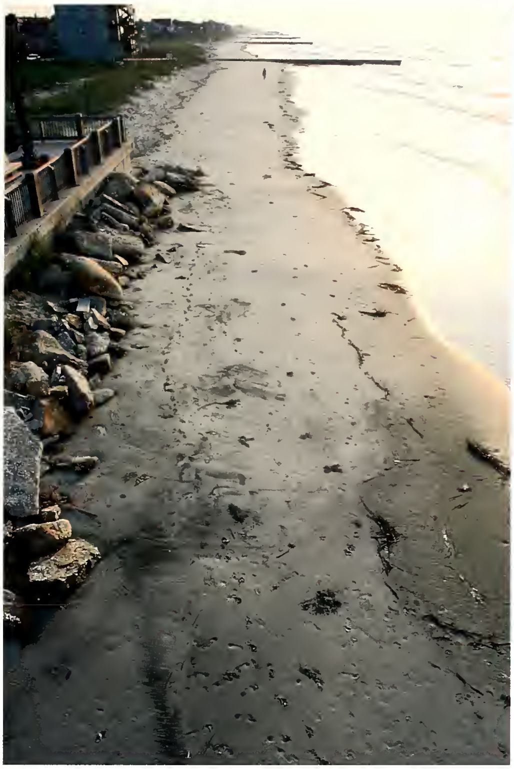
Fishermen also struggle against the loss of fishing grounds to the activities of other industries. Oceanic oil and gas development, especially, has left a trail of debris that regularly damages or destroys gear, and offshore platforms and pipelines themselves are barriers to some fishing gears (they are, at the same time, wonderful attractors of fish). Ship spills of toxic chemicals foul fishing grounds and kill fragile larvae that would have been the following year's catch.

Habitat Loss

Habitat degradation poses another serious problem that threatens the viability of many fish stocks, especially those inhabiting inshore areas at some time of their life—a very large number. Pollutants—toxic industrial chemicals and heavy metals, petroleum hydrocarbons and drilling compounds, herbicides and pesticides, freshwater runoff and thermal plumes, human and animal excrement, medical wastes, and others—not only kill fish and

Docks are increasingly displaced by more profitable facilities, such as Mississippi's immense gambling casinos. *Lauri Lawson, NOAA Fisheries*

GRAND CASINO
LADY LUCK



ALEC OWEN MAITLAND

LEFT: A series of wooden groins tries to halt erosion of the vanishing sands in Folly Beach, South Carolina. *William B. Folsom, NOAA Fisheries.* **RIGHT:** A ship aground in the Florida Keys is surrounded by floats to prevent spilled fuel from reaching the fragile reefs. *Office of Habitat Conservation, NOAA Fisheries.* **BELOW:** Global warming may disrupt the economies of coastal fisheries as far north as Alaska. © *Allen M. Shimada*

BARBARA ANN
STORMY ELIZABETH
CHARLESTOWN, R.I.

Offshore lobsters are taken by this Pt. Judith, Rhode Island, commercial fishery fleet. *William B. Folsom, NOAA Fisheries*

shellfish outright, but perhaps more devastatingly, produce sublethal effects that weaken them and reduce their generative capability. Nearshore fish habitats are also damaged by coastal development and other human activities. Massive wetland losses result from dredging and filling operations, oil and gas exploration and transportation, mining, hydropower dams, and channel and river diversions. Ship groundings and hazardous spills turn fragile coral reefs into stark wastelands, groins and jetties accelerate beach erosion, and increasingly heavy boat traffic chases fish from formerly quiet-water areas.

Natural processes take a toll, too, in the form of subsidence, overheating, earthquakes, tsunamis, hurricanes, and heavy winds. Marshes, coastal beaches and barrier islands, mangroves, coral reefs, and bay systems are particularly vulnerable, but even the open ocean is sensitive to change. Two other natural perturbations may be especially damaging to fisheries: global climate warming and El Niño events (the periodic intense warming of oceanic waters). El Niños usually produce massive kills of anchovy and other forage species, although seldom in U.S. waters. But they have an impact all the way up the food chain, affecting the availability of tuna, marlin, and other species sought by American commercial and recreational fishermen. Temperature shifts usually disrupt normal distribution patterns of fish, too, with substantial portions of a stock vanishing from American waters, sometimes to emerge as unexpected bounty for Canadian fishermen before the resource returns to U.S. territory. Farmers, too, feel the wrath of climatic shifts, but fishermen feel especially helpless: at least farmers' wheat doesn't wander across the border to take up residence in a Canadian field.

TERMINOLOGY

The term "fishery" has many meanings other than the taking of fish: a group of fishermen ("the commercial fishery" and "the recreational fishery"); the catch of a specific sea animal ("the tuna fishery"); a place for taking sea products ("the Puget Sound fishery"); the privilege of taking fish in certain waters ("the American fishery"); the technology used to take fish ("trawl fishery" and "longline fishery"); and the branch of knowledge—science, economics, and sociology—concerned with the taking of fish (thus, many American universities have "schools of fisheries"). All these terms are used in this book, with a reliance on the context for clarification. A general glossary of some frequently used terms is appended.

There is little agreement about the use of "fishery" versus "fisheries." The literature seems generally determined to avoid definitive usage, so in this book, both terms are used as they seem appropriate. Where the term "commercial fishery" or "recreational fishery" is used, the intent is for inclusiveness of all participants and activities in the United States, including businesses and organizations involved in that enterprise.

CAUTIONARY NOTES

The National Marine Fisheries Service respects the rights of people who believe that humans should not consume living beings, including fish. Certainly, seafood isn't a necessary part of everyone's diet. Nevertheless, the agency is dedicated to the stewardship of America's fisheries resources, and the primary use of those resources—whether by commercial or recreational fishermen—is for consumption.

In illustrating the importance of fisheries to the nation's economy, *Neptune's Table* portrays a number of restaurants, seafood markets, recreational fishing facilities, and other commercial interests. Because depicting all the enterprises dependent on the nation's fishery resources was impossible, the entities included should in no way be interpreted as an endorsement of any establishment, product, or service by the National Marine Fisheries Service or by the author. The privacy of the fishing community and its facilities has been respected, and no pictures have been included where the subjects did not give their permission.

RIGHT: Only a few California fishermen are permitted to work in the historic Newport Beach dory fleet fishery. *William B. Folsom, NOAA Fisheries.*
BELOW: This family fishing in the Laguna Madre in Texas is part of the vast U.S. recreational fishery. *William B. Folsom, NOAA Fisheries*

EVINRUDE
TX 54

Once the ultimate luxury food, American lobster is today within reach of almost anyone's wallet. *William B. Folsom, NOAA Fisheries*

SOURCE MATERIALS

This book draws upon a wealth of published and unpublished information; a list of specific references may be found at the end of the book. Statistical information was taken from published reports of the Department of Commerce's National Oceanic and Atmospheric Administration. Especially important in providing general background information and insight into the views and needs of commercial and recreational fishing interests were such trade publications as *National Fisherman, Pacific Fishing, Commercial Fisheries News, Alaska Fisherman, Salt Water Sportsman*, and many others. Other major information sources follow for each of the chapters of this book.

The Fisheries Dominion

Baird's Legacy: The History and Accomplishments of NOAA's National Marine Fisheries Service, 1871–1996, W. L. Hobart, editor; *Crisis in the World's Fisheries,* James R. McGoodwin; *The First 50 Years,* National Fisheries Institute; *Fisheries Ecology,* Tony J. Pitcher and Paul J.B. Hart; *A History of Fishing,* Dietrich Sahrhage and Johannes Lundbheck; *Our Changing Fisheries* and *Our Living Oceans,* U.S. Department of Commerce; *Fish Catching Methods of the World,* Andres von Brandt; and *Federal Conservation and Management of Marine Fisheries in the United States,* John P. Wise.

A Hard Living

Anthropology of Fishing, James M. Acheson; *An Appraisal of the Social and Cultural Aspects of the Multispecies Groundfish Fishery of New England and the Mid-Atlantic Regions,* David Griffith and Christopher L. Dyer; *Crisis in the World's Fisheries,* James R. McGoodwin; and *Sociocultural Aspects of Fisheries Management,* Richard Pollnac and Susan Littlefield.

Tools of the Trade

Solving Bycatch: Considerations for Today and Tomorrow, Alaska Sea Grant Program; *Fisheries Ecology,* Tony J. Pitcher and Paul J. B. Hart; *Our Changing Fisheries,* U.S. Department of Commerce; and *Fish Catching Methods of the World,* Andres von Brandt.

The Atlantic Bounty

Crisis in the World's Fisheries, James R. McGoodwin; *The Fish and Fisheries of Colonial North America,* John C. Pearson, editor; *A History of Fishing,* Dietrich Sahrhage and Johannes Lundbeck; *Our Changing Fisheries* and *Our Living Oceans,* U.S. Department of Commerce; *Distant Water: The Fate of the North Atlantic Fisherman,* William W. Warner; *Federal Conservation and Management of Marine Fisheries in the United States,* John P. Wise; and many articles from *Commercial Fisheries News, National Fisherman, Salt Water Sportsman,* and university Sea Grant Program publications.

Pacific Treasures

Crisis in the World's Fisheries, James R. McGoodwin; *Faces of the Fisheries* (6 volumes), North Pacific Fishery Management Council; *A History of Fishing,* Dietrich Sahrhage and Johannes Lundbeck; *Our Changing Fisheries* and *Our Living Oceans,* U.S. Department of Commerce; *Fishing Methods of the World,* Andres von Brandt; and many articles from *Pacific Fishing, National Fisherman, Salt Water Sportsman,* and university Sea Grant Program publications.

The World Below the Brine

The world below the brine,
Forests at the bottom of the sea, the branches and leaves,
Sea-lettuce, vast lichens, strange flowers and seeds, the thick tangle, openings and pink turf,
Different colors, pale gray and green, purple, white, and gold, the play of light through the water,
Dumb swimmers there among the rocks, coral, gluten, grass, rushes,
and the aliment of the swimmers,
Sluggish existences grazing there suspended, or slowly crawling close to the bottom,
The sperm-whale at the surface blowing air and spray, or disporting
with his flukes,
The leaden-eyed shark, the walrus, the turtle, the hairy sea-leopard,
and the sting-ray,
Passions there, wars, pursuits, tribes, sight in those ocean-depths, breathing that thick-breathing air,
as so many do,
The change thence to the sight here, and to the subtle air breathed
by beings like us who walk this sphere,
The change onward from ours to that of beings who walk other
spheres.

– Walt Whitman, *Sea-Drift, Leaves of Grass,* 1860

1

Gollott's
BRAND
SEAFOOD

2

SEAFOOD MARKET
319-F
DIRECT OFFICE
BOATS

FISHERIES AS IMAGE AND ICON

The ocean world, with its fascinating creatures and mysterious depths, is everywhere conveyed to the public through art and symbols—some of them quite imaginative. Impressive paintings and sculptures adorn seafood restaurants and markets, hotels and docks, boats and trucks. A few of the thousands of these artistic treasures are shown here.

7

LITTLE
CHINOOK'S
FISH N CHIPS

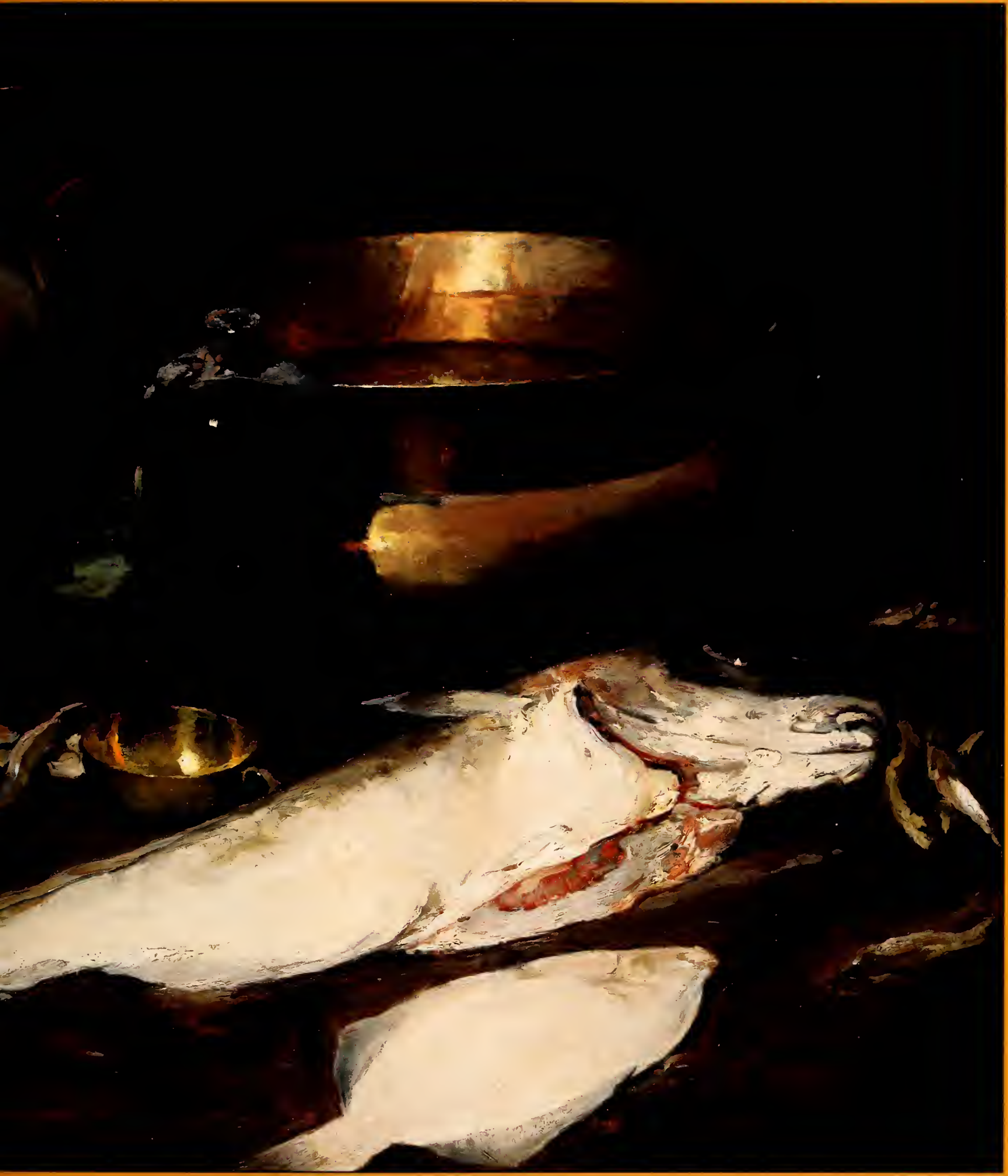
1 Even this off-the-beaten-path warehouse in Biloxi, Mississippi, sports a proud bit of art announcing its trade. 2 Many seafood markets, like this one in Madeira Beach, Florida, seem to work on the assumption that customers like to see what their next meal looked like when it was alive. 3 This Florida Keys motel has fancifully—and colorfully—recreated a reef scene in its front yard. 4 A boardwalk café in Newport Beach promotes its name in a T-shirt style well suited to Southern California. 5 A Folly Beach, South Carolina, legal firm advertises its services with a sense of humor. 6 Neon-pink is unusual in outdoor art, but seems perfect for the queen conch adorning this Florida Keys lodge. 7 The noble salmon, which commands a place of honor as an artistic as well as a culinary icon, works admirably for this Seattle eatery. *Photos by William B. Folsom, NOAA Fisheries.*

Baja
SHARKEEZ
SurfMex
MESQUITE BROILER
4

Emil Carlsen
Detail from *Still Life with Fish*
Chester Dale Collection
Photograph 1998 © Board of Trustees, National Gallery of Art, Washington

2

THE FISHERIES DOMINION



This chapter looks at the various sectors that comprise U.S. fisheries: the commercial and recreational fleets, aquaculture, product safety, markets and trade, and management and science. It is intended as an overview of activities and conditions that generally apply to the nation as a whole; subsequent chapters deal specifically with America's Atlantic and Pacific fisheries.

THE COMMERCIAL SECTOR

Although this book often refers to a "commercial fishing industry," in reality the sector is a collection of individual fisheries, fleets, and markets, with great diversity in each component. The U.S. commercial fishing fleet itself is extraordinarily diverse in terms of vessel size and gear. Even within a fishery, vessel size varies greatly, usually in response to the area fished (for example, small inshore boats versus large offshore ones). Boat size also varies as a consequence of personal preference, available funding, cultural traditions, local geographic conditions, and many other factors. But increasingly, vessels of every size are becoming "multipurpose," as their owners target different species, using different gear, and often on the same trip.

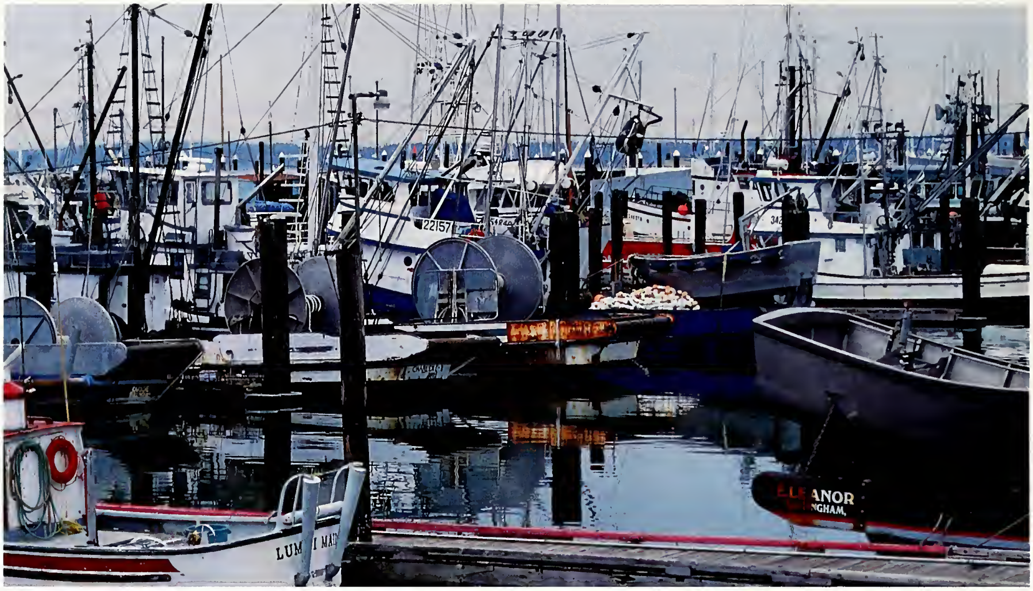
American ocean-fishing vessels constitute about 3 percent of the world's fishing fleet. Very large fleets populate Alaska, Washington, Louisiana, Florida, and North Carolina, but many other states also boast an impressive number of boats.

ABOVE: Not all commercial boats stay in the water. These Newport Beach, California, dories are trailered daily. © *William B. Folsom, NOAA Fisheries.* **BELOW:** Seattle is home port to many North Pacific freezer-trawlers that frequently offload their cargo in Alaskan ports. © *Allen M. Shimada*

Some indication of America's importance overall as a fishing power is shown by the fact that in 1995, its fleet was the world's fifth largest producer of seafood by weight, harvesting almost 6 percent of the world catch. (China harvested 17 percent; Peru and Japan, 8 percent each; and Chile, 6 percent.)

The number of motorized vessels used to catch fish has seen an extraordinary increase since the 1950s; in actuality, more and more vessels have been catching roughly the same amount of fish for the past 40 years. In addition, advances in gear and vessel technology have meant that today's vessels are highly efficient, finding and bringing their catch aboard in a fraction of the time formerly required. Much has been said of "fleet overcapitalization," a situation where the investment in vessels, gear, licenses, and other capital costs exceeds what is actually needed to harvest the allowed catch. In fact, many of the nation's fisheries have an excess harvesting capacity. And quite recently, small, federally sponsored "vessel buyout" programs have been implemented where such excess capacity is a factor in serious overfishing.

FACING PAGE: Maine generations. © *Nance S. Trueworthy*



On all coasts, harbors like Squalicum, Washington, are filled with more boats than are needed to harvest the stocks. *William B. Folsom, NOAA Fisheries*

One unforeseen problem with this approach is that, sometimes, decreasing the number of boats causes the remaining vessels to exert even greater pressure on the stocks. Overcapacity is a factor in many U.S. fisheries.

In the late 1800s, the U.S. fleet evolved from sailing vessels to steamers, and in the early 1900s, to schooners with auxiliary gasoline-powered vessels. By the 1930s, though, vessels were larger, faster, and diesel-powered, allowing them to fish in ever more distant waters. And the vast new labor force of the era—the flood of immigrants from Portugal, Italy, Greece, Scandinavia, and China—provided experienced fishermen eager to reap the abundant resources of their new home.

Early 20th-century Seattle saw the transition from dories to diesel-powered vessels. *Fishermen's Terminal, Seattle, c. 1919, Museum of History & Industry, Puget Sound Maritime Historical Society. All rights reserved.*

Seaplanes like this one in Anchorage help the fleet locate commercial concentrations of fish. © *William B. Folsom Photography, Inc.*

Even before this mechanization, however, sophisticated gear had become available, as discussed later in this book. Purse seines were in use in Alaska by 1870, longlines in 1885, and otter trawls for groundfish and shrimp in the early 1900s. The age of factory ships, which ushered in the great expansion of Alaskan groundfish harvesting, began in 1954.

Other important innovations contributed to the American fleet's great efficiency (and, in many cases, severe stock declines): onboard refrigeration, special power blocks for retrieving seine nets, multiple trawls, and durable nylon and synthetic fiber for nets. Electronics advanced to assist with navigation, communication, and location of both fishing grounds and the fish, and fishermen began to deploy seaplanes and helicopters to locate aggregations of target species. Irrespective of these technological advances, total domestic commercial harvesting—excluding the recent massive Alaska groundfish catches—has increased only marginally since World War II. And even these Alaska harvests were at the expense of the large foreign operations that dominated the area from the early 1960s to the mid-1980s, so the overall marine catch didn't change significantly. Competition is fierce today in most American fisheries, with some commercial fishermen barely making enough to pay their expenses. Others, of course, make a comfortable—even handsome—living.

RECREATIONAL FISHING

Fishing is considered recreational when the primary motivation is pleasure, amusement, relaxation, or subsistence. However, the recreational and commercial fishing sectors are indeed interdependent and have much in common: both depend on renewable fishery resources and healthy marine ecosystems; they often fish for the same species; and they're supported by the same wharfside service industries—docking, ice and fuel, repairs, and equipment sales.

In addition, some recreational fishing blurs the line between the two sectors. Much recreational fishing is done from charter boats, which usually take private parties up to six or so on customized fishing trips sometimes lasting several days, and from "head boats" and "partyboats," which take up to 60 paying passengers on half-day or full-day fishing trips. The vessel owners, captain, and crew are indeed participating in "commercial" operations, and the health and availability of fish stocks are as critical to them as to fishermen who sell their catch. These operations must have an array of permits and licenses, and are subject to enforcement of catch regulations and safety rules.

Recreational fishing and commercial operations also intersect where commercial baitfish boats supply their catch for use by recreational fishermen, and often share marinas and support services. And, unfortunately, recreational fishermen sometimes sell or barter their catch (ignoring regulations in some areas that prohibit this practice). In so doing, they lower prices for commercial catches, and sometimes entirely eliminate local seafood markets.

In their quest for a fair share of the fisheries "pie," recreational fishermen often—legitimately—claim theirs is the more valuable

The eye—and wallet—are dazzled by the array of equipment in specialty shops like this store in San Diego. *William B. Folsom, NOAA Fisheries*

PARAMOUNT
PARAMOUNT
BOGAN'S BASIN • BRIELLE, N.J.

ABOVE: A head boat filled with satisfied customers returns to its home port of Pt. Pleasant, New Jersey. *Edward J. Pastula, NOAA Fisheries.* **BELOW:** Bait shacks like this one in Pascagoula, Mississippi, often cater to both commercial and recreational fishermen. *Lauri Lawson, NOAA Fisheries*

M&M
LIVE BAIT
TACKLE
BEER
ICE
LIVE SHRIMP
BULL MINNOWS
ICE

sector. Annually, between eight and nine million people make fishing trips along America's coastlines, catching more than 300 million fish. As conservation concerns grow, many of these fish are released alive under catch-and-release programs. Unfortunately, many released fish subsequently die as a result of their capture. So issues of fish mortality exist for this sector as well as for commercial fisheries.

In some regions, recreational interests argue vigorously against the commercial sector's exploitation of a species that they themselves have no interest in catching. Usually, the species (for example, Florida's Spanish sardine and California's *Loligo* squid) is critical forage for favored game species—billfish, tuna, and mackerel.

The value to American society of recreational saltwater fishing shouldn't be underestimated. In fact, many commercial fishermen also enjoy recreational fishing. But turn-around is fair play here: anglers often select seafood items in their frequent restaurant visits. So while these two sectors sometimes wrangle over the size of their particular slice of the fisheries pie, very few of them probably wish to deprive others of their share. Each sector contributes hundreds of millions of dollars to the economy, creates many thousands of paying jobs, and has the privilege of pursuing fish. It is the never-ending and often thankless chore of managers to determine how to best divide the pie.

FARMING THE SEA

It is sometimes suggested that fish farming offers good prospects for unemployed fishermen, if only they'd start up such operations. Aquaculture does indeed offer the potential for supplying a variety of high-quality products at reasonable prices, and for making available some species while their depleted stocks are recovering. Aquaculture may even enhance some jeopardized stocks through the addition of young laboratory-spawned fish. But its heavy start-up and maintenance costs and highly technical nature make it an unlikely alternative career for commercial fishermen at this time.

In fact, aquaculture often goes head to head with commercial fisheries products, competing for market share even if the commercial fisheries are in good shape, as with Alaska salmon. In that case, aquaculture isn't so much of a salvation to commercial fishermen as it is an aggravation and market competitor that threatens the commercial fisheries just as much as any downturn in market prices. This problem may be further exacerbated if the cultured products are coming from heavily subsidized foreign operations and competing

Shallow Florida bays offer good angling for bonefish, a species reserved exclusively for recreational use. *© Jeff Greenberg/Unicorn Stock Photos*

ABOVE LEFT: Larval clams (spat) are produced under tight control at this aquaculture operation in South Carolina. *William B. Folsom, NOAA Fisheries.* **ABOVE RIGHT:** Coastal aquaculture ponds produce a surprising amount and variety of the nation's seafood and baitfish. *Courtesy of National Fisheries Institute.* **LEFT:** A South Carolina clam aquaculture operation raises both the spat (open tanks) and the green algae they eat (background cylinders). *William B. Folsom, NOAA Fisheries*

for the commercial fishermen's high-end customers.

Fish farming does have some advantages over the fishing of wild stocks. It reduces much of the uncertainty associated with wild stocks by controlling as much as possible all stages of the fish's life—spawning, egg production, and rearing. Most cultured marine products today are part of heavily mechanized systems that rigorously control both the animals and their environment, although simpler "mom-and-pop" aquaculture operations still exist in some rural areas. And the field's rapidly expanding technology is changing the composition of many cultured products to make them more wholesome and appealing. Farmers can adjust the cultured species' diet and alter fatty acid levels, thereby extending shelf life and storage stability and enhancing the color, flavor, and aroma of the flesh.

Yet farming fish has its own dangers, which threaten the pocketbook rather than lives. Cultured fish are especially subject to disease, parasites, and nasty weather—droughts, blizzards, tornadoes, and hurricanes. Cultivation also entails some species' precocious sexual development, unwanted breeding, cannibalism, and sometimes such nearshore "robbers" as seals and porpoises. Fish farmers must compete for increasingly valuable coastal lands, and good markets are by no means a given, especially where many growers are culturing the same species and competing with the low labor costs of foreign growers. And expenditures for feed, electricity, technicians, water treatment systems, eggs or broodstock, and even land acquisition can be extensive.

Nevertheless, the potential American market for cultured seafood products is very large, if volatile, and includes just about any imaginable kind of fish or shellfish. In fact, the majority of shrimp eaten in the United States is cultured, although most of it is from South American and Asian ponds. A ready market also exists for eggs and larvae of shrimp and other culture organisms; American innovation and

PRODUCED IN THE USA BY ATLANTIC SALMON OF MAINE, INC.
MAINE
ATLANTIC SALMON
Campbell's CHUNKY
New England Clam Chowder
OLDE CAPE COD
Local Favourites
NATURAL NEW ENGLAND CHOWDER
Doxsee CHOPPED CLAMS
IN CLAM JUICE
ATLANTIC Clam Juice

know-how have made impressive gains in this area. There are also markets for cultured seaweeds and inedible items, such as shell and coral produced in Western Pacific lagoons and ponds.

The largest U.S. saltwater culture operations are for salmon, both Atlantic and Pacific forms. And recent success in raising tuna, snapper, and other high-value species suggests that consumers will increasingly see fine aquaculture products on the dining table. Although most saltwater ("mariculture") operations are either shoreline ponds or open-coast pens, the availability of artificial saltwater systems makes possible fish farms far from coastal acreage where land values are often prohibitively high for farm operations. Although small mom-and-pop aquaculture operations are common in some parts of the country, much of the marketed product comes from large corporate farms with deep pockets that can afford to subsidize years of losses while building a solid market share.

The barriers to continued aquaculture growth are quite formidable. First, detailed scientific information about the biology of most marine species is in short supply—exceptions are salmon, oyster, shrimp, and some tropical fish: How much food, and what kind, is necessary at each life stage? What are the optimal temperature, oxygen, and salinity conditions for each? When does the animal reproduce? How much crowding can occur? What are the principal diseases and parasites, and how can they be managed? Second, culture systems differ substantially according to species, desired size at harvest, and local growing conditions, but engineering has lagged in this area. Implementing culture systems without understanding both biological and engineering requirements may well be ruinous to the aspiring farmer. And finally, even where the animal's requirements are known, the costs of equipment, supplies, and labor may simply make culturing unprofitable.

In addition, culture systems themselves can pose some significant problems to society. Great care must be taken to prevent fish wastes, including unused feed, from being transported into the surrounding habitat, where they can contribute to toxic algal blooms and other ecological imbalances. There are also forensic issues, such as the difficulty in distinguishing between cultured fish that are sold for optimal profits at a size below the legal minimum for the same species in the wild. Also, scientists are concerned that releasing cultured fish into the wild may diminish local biodiversity—a very real problem that has already surfaced after years of hatchery salmon releases, and that may threaten the viability of native species. There is also concern that escaped cultured species could replace native species, and could damage both cultured and wild species by introducing exotic diseases. As with problems affecting America's wild stocks, the industry's hope lies in better scientific information and sound management policies.

TOP: Aquaculture has returned oysters to a top spot on the American seafood buffet. *William B. Folsom, NOAA Fisheries.* **INSET:** Farmed salmon, such as these from Maine, dominate the U.S. marine aquaculture market. © *William B. Folsom Photography, Inc.* **BOTTOM:** Increasingly, processed clam products use resources supplied by aquaculture to supplement the wild stock harvest. *William B. Folsom, NOAA Fisheries*

MARKETING THE DAY'S CATCH

LONG JOHN SILVERS
SEAFOOD

Chain seafood restaurants require a steady supply of high-quality, standardized products. © *William B. Folsom Photography, Inc.*

Fishermen themselves have difficulty selling their catch directly to the public. Doing so might bring them a better price, but is nearly impossible because their at-sea schedules are basically incompatible with shore-based market openings and closings. But fishermen have another unique problem that makes their selling position weaker than that of other food producers: they can't simply withhold their catch until the price is higher ("fresh" fish doesn't stay fresh very long!). In the few instances where fishermen are able to maintain their catch alive in tanks or ponds, as with Maine lobster and some aquaculture species, fish producers have a much better bargaining position than those who have no choice but to sell their more perishable catches immediately.

Historically, fishermen's weak selling position has been improved by an established long-term relationship with their buyers, to whom they provide a steady supply of the day's catch. A skipper can't necessarily count on the dealer's offering top price on a specific day, since dealers buy from many vessels, and by the time a hopeful captain heads back to port, the dealer may already have bought what he needs for a fluctuating market. The skipper or vessel owner must then hurry to contact other buyers, or settle for the far lower price a buyer may offer if he's willing to stockpile ("warehouse") the surplus. Of necessity, the negotiating is usually done by phone or radio, while the vessel is still at sea, and buyers who break a verbal agreement aren't very welcome on the docks.

It's not difficult to understand why warehousing fish drives down the price paid to fishermen. The majority of fresh or

Most seafood is sold through markets, like Seattle's Pike Place Market, or directly to processors and purveyors. *William B. Folsom, NOAA Fisheries*

PIKE PLACE FISH CO.
We pack
First of the Season
Fresh Halibut

A McLean, Virginia, seafood market employee tends live lobsters from New England. *William B. Folsom, NOAA Fisheries*

Sauvignon Blanc

SUKIJI SEA FOOD
S M FISH COMPANY
LOBSTER FISH
OYSTERS And CLAMS

New York's Fulton Fish Market has been operating for more than 150 years. *Courtesy of Pacific Fishing magazine*

fresh-frozen American seafood goes to restaurants, which need to keep menu prices relatively stable. Seafood dealers have to provide the restaurants with a steady supply of fish. So they try to maintain large inventories, and usually end up paying fishermen a set price, regardless of known variations in availability. As a result, when catches are abundant, dealers may simply fill warehouses, but drop dockside prices lower and lower until fishermen are hardly making any profit or are even taking a loss for the trip.

Many fishermen have seen this unavoidable exclusion from the market process as a distinct disadvantage, and some regard sudden dockside price fluctuations as conspiracies by dealers and processors. In fact, though, price fluctuations are part and parcel of an unsubsidized market open to competing foreign products. And though fish prices are often below what fishermen think they should get, the American system creates some other incentives to maintain ties to certain buyers. Dealers and brokers often provide access to credit, capital for long-term investment, preferential prices in unstable markets, valuable knowledge about market conditions, and other shoreside support services (ice, fuel, food, and bait, for example). As "fish auctions" have become more common, these marketing relationships have also changed.

There is some specialized fish buying that doesn't fit the usual fresh-fish marketing system. Vessels loaded with fish destined for fishmeal and fish oil, such as menhaden, have a far closer, more direct relationship with the few fish plants where they unload; there are no middlemen or

A large freighter discharges frozen albacore at a tuna cannery in Mayagüez, Puerto Rico. *William B. Folsom, NOAA Fisheries*

Bins of meticulously tended fish are viewed by prospective buyers at Maine's Portland Fish Exchange. © *Nance S. Trueworthy*

buyers. Aquaculture producer–processor partnerships are also much closer; in fact, some firms operate both "fish farms" and processing facilities, and some seafood companies today operate their own vessels or directly contract with vessels, such as in the east coast surfclam and ocean quahog fisheries.

A more complex system exists for North Pacific pollock, which is processed into surimi, the paste used for "artificial" crab legs, lobster, and other "analog" products. This catch is often unloaded and processed aboard giant factory ships far out at sea. But many independent vessels unload at shoreside processing plants in Alaska, and there are sometimes fierce "inshore–offshore" allocation battles reflecting marketing competition between these sectors. In fact, some shoreside plants buy fishing vessels specifically to ensure that deliveries continue, as in the Alaska pollock fishery in past years.

Still another complex marketing system serves today's tuna canneries. Where once American tuna boats tied up next to the dockside plants to unload their fish, tuna captains now often sell their catch over the side to large seafood freighters plying massive stretches of the ocean. These specialized tuna freighters receive fish from boats sailing under many flags, unloading the entire frozen shipment at canneries in Puerto Rico, in American Samoa, or in foreign countries only after several months of buying.

Like so many commodities, fisheries markets are generally in a state of flux. Imports of high-value products are increasing as a result of many factors, including growing demand for products that can be cheaply supplied by other countries, expanded aquaculture, the availability of previously untapped foreign resources (New Zealand's orange roughy, Chile's kingklip, and Mexico's escolar), and aggressive foreign marketing.

This working fish market cooperative in Newport Beach, California, is a state historic site. *William B. Folsom, NOAA Fisheries*

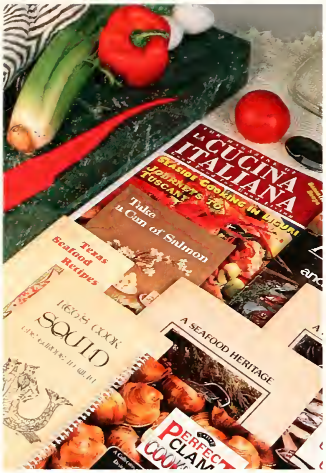
THE *Entrepreneurial* SPIRIT

Judy David embodies American enterprise: she not only operates a fishing vessel, but also processes and markets her catch—in this case, bait shrimp for recreational fishing boats working out of Biloxi, Mississippi.

Not so long ago, the nation's fisheries were largely characterized by entirely separate sectors: some people fished, others processed the catch, and often, still others marketed the product. Of course, there were always a few enterprising (or perhaps just very energetic) souls who both caught and sold the catch, but for the most part, each operation was performed by a different individual.

Today, though, a great many fishing families are active not only in catching the product, but in processing and marketing it, as well. The U.S. fishing industry today sees much more such "vertical integration," which can take many forms and offer substantial financial benefits in this highly competitive industry. In some cases, like Judy's, the multi-structured operation is fairly small. But even so, it offers a real advantage: when age or inclination suggests it's time to cease the physically grueling fishing part of the operations, one can still profit handsomely in the marketing end. In some other fisheries, though, large processing plants and canneries now own and operate—or retain under exclusive charter—the harvesting vessels themselves. So the clams you had for lunch may have been caught, processed, and marketed by a single company.

Judy David, D'Iberville, Mississippi (Lauri Lawson, NOAA Fisheries)



Recipe books, pamphlets, and specialty magazines have substantially helped create the strong demand for seafood. *William B. Folsom, NOAA Fisheries*

A particularly promising marketing system, one generally favored by fishermen, is the "fish auction," patterned after the sophisticated Japanese fish auctions that provide high-quality products commanding top prices. These are still rare in America, but the Portland (Maine), New Bedford and Gloucester (Massachusetts), and Honolulu auctions bring fishermen good prices for fine-quality fish and have begun to show fishermen the potential profits from better handling of their catch. Fishermen-funded marketing groups, with crew members actively selling their product at supermarket promotions, have also sprung up, with Alaska leading the pack.

Some ports have established fishing cooperatives. Along the coasts of Rhode Island and New Jersey, for example, small-scale fishermen sometimes band together to ensure steady markets and higher prices for their catches. Member fishermen forego competition among themselves—and sometimes higher prices—to reduce the risk of uncertainty and distribute the benefits among people who are often their relatives or neighbors. Such cooperatives are more common in countries outside the United States, but American cooperatives have also arisen to protect domestic markets from foreign seafood imports.

There are also seafood cooperative marketing groups, usually promoting the products of individual states. These councils and boards derive their operating funds from fishermen and processors in the participating fisheries. But they differ from dairy and beef marketing groups, which promote buying generic industry products in favor of purchasing a specific state's seafoods.

SEAFOOD PROCESSING

The American public generally sees seafood at its initial stage (being unloaded from boats) and in its final stage (on the table). The complex chain of individuals and organizations involved in processing seafood, like most food production, is largely unseen. It includes primary processors who purchase the raw fish products from vessels or importers, and either transform them into a final product or deliver them to the various levels of secondary processors who do. The chain also includes wholesalers, who distribute the processed products to the retail sector—grocers, seafood markets, and restaurants. All along the way are assorted buyers, brokers, agents, shippers, and inspectors.

As in the harvest sector, seafood processing has seen revolutionary technological advances. The modern canning process originated in France in the early 1800s. By 1878, Alaska was canning salmon; California began canning tuna soon thereafter. Cold storage and freezing plants to store excess harvests were established as early as 1892, and efficient filleting and packaging techniques were introduced during the 1920s. America's first distant-water cold storage plant was built in Costa Rica in 1936, allowing vessels to offload

LEFT: Picking cooked blue crabs along Maryland's Chesapeake shore is seasonal work but requires considerable skill. © *William B. Folsom Photography, Inc.*
RIGHT: Canning salmon provided new job opportunities for turn-of-the-century Seattle workers, especially immigrants. *Special Collections, University of Washington Libraries, photo by Ashel Curtis, negative #27677*

KAYLER-DAHL
COLD STORAGE

Dockside cold storage facilities, such as these in Petersburg, Alaska, are a common sight in most fisheries ports. *Scientific Publications Unit, NOAA Fisheries*

fish far from domestic ports. But perhaps the single-most important processing development was by a man with a household name by the mid-20th century. Clarence Birdseye found a way to quick freeze skinned and filleted fish, and thereby transformed the nation's fish-eating habits. Another major, but more recent, breakthrough was the development by Bob Gruber of frozen 20-pound fish blocks in the 1960s. This permitted the frozen fillets to be cut by bandsaw into the small squares used for fish sticks and fish portions. These market forms catapulted fish to fame as the "fishwich" popular today in school lunches and in fast-food restaurants.

American seafood processing and marketing are today multibillion-dollar industries. The overall number of processing plants has remained fairly constant since 1982, though it rose somewhat in the late 1980s in response to the growth of Alaskan fisheries. Total employment in wholesale plants peaked in 1989, and in processing plants, in 1991. Jobs have now declined somewhat as technological advances have reduced labor requirements—and the number of larger plants in the fish processing business.

Of course, the processing sector depends on the harvest sector—fishermen—and is thus subject to sometimes wide variations in product availability and market price. Some processing firms compensate by diversifying, processing more than one species or product. Others simply close down production for parts of the year. But this seasonal work has an impact on the workers and the community.

"Overcapitalization," much lamented in the harvesting sector, also takes place in seafood processing. In some fisheries, much of the harvested catch isn't sold fresh, but must be further processed. Or much of it is harvested in a short time, as when there are restricted harvest seasons or catch quotas. In both cases, this high product volume gives firms an incentive to build larger processing plants than are necessary for much

A great deal of the North Pacific groundfish catch is processed on board immense freezer-trawlers. *Courtesy of Pacific Fishing Magazine.* **INSET:** The multimillion-dollar American pet food industry has created a significant niche for fish products. *William B. Folsom, NOAA Fisheries* of the year. Such excess plant capacity and higher costs can limit the number of firms. Where just a few firms are operating, they can influence—and generally reduce—the price paid to fishermen for their product.

TRADING WITH THE WORLD

America's global seafood trade in part reflects conditions in its own fisheries—the availability of domestic stocks. Each year, the United States imports about 3 billion pounds of seafood worth almost $7 billion. The nation also ships to overseas markets about 35 percent of its domestically caught seafood, worth about $3 billion. America is the world's primary exporter of seafood products in terms of value, and is the second largest importer, trailing only Japan.

The most valuable U.S. seafood exports are Alaska groundfish surimi, salmon, crab, and caviar (pollock roe). Together, these products are worth more than 60 percent of the nation's seafood exports. Salmon is America's most valuable seafood export, although shrimp and lobster are also very important. Japan is far and away America's best seafood customer, but Canada and Europe are also important markets for U.S. fish products. Of seafoods imported to America, shellfish—shrimp, lobster, scallop, and crab—are the most important, especially shrimp, but canned tuna is also a large import.

From fishermen's viewpoint (though not necessarily that of the processors), obtaining a favorable global trade position for U.S. fisheries products means exporting more than importing. This goal is hampered by several barriers. American exporters face hefty foreign tariffs, import quotas, and "import licenses"; must comply with restricted processing or handling and storing methods; and must conform to other nations' standards for mercury and other contaminants. Of course, America also imposes some of these same restrictions, especially seafood quality standards, and prohibitions on the import of fish products whose capture involves killing such protected species as sea turtles and dolphins.

The North American Free Trade Agreement (NAFTA) was intended to reduce or eliminate some of these barriers among its partners—Mexico, Canada, and the United States—which have substantial seafood trade relationships. Many in the U.S. fishing industry hope that reducing trade barriers will eventually expand seafood exports to its current and potential trading partners, such as Chile.

FRIED FISH
NET WT.: 3 oz (85g)

Imported specialty seafoods have flooded the U.S. market to meet the needs of recent immigrants. *William B. Folsom, NOAA Fisheries*

ABOVE: A shipload of herring roe bound for Asia is brought alongside a Japanese vessel off Togiak Bay, Alaska. © *Allen M. Shimada.* **BELOW:** The ability to air-freight America's fresh seafood has expanded both its exports and its domestic distribution. *William B. Folsom, NOAA Fisheries*

WORLD
AKN0056 UA

THE SEAFOOD-LOVING PUBLIC

Americans' consumption of fish and shellfish has gradually but steadily increased over the past half century. Per capita consumption increased from just under 10 pounds in 1945, representing a national total of 1.3 billion pounds, to about 15 pounds a year. This rate has remained static for several years, and isn't expected to change very much in the near future. It actually represents a very large overall increase in seafood consumption because the U.S. population itself has grown. Today the nation eats almost 4 billion pounds of fish and shellfish each year. A great deal of fishmeal is also produced, and although it isn't eaten directly, it's an important component of feeds for poultry and aquaculture species.

Some of the expanded seafood use has resulted from increased domestic production. The years following World War II saw the development of a large American distant-water fishing fleet, new harvesting technologies, and progress in aquaculture. Nevertheless, the nation has often imported more seafood than it has exported, and today, about half the seafood eaten in the United States is caught by foreign fleets. Both the industry and nutritionists have pointed to seafood as a tasty, low-fat, healthy food choice. Many Americans consume large quantities of fish oil supplements to enhance their health and increase their longevity.

About two-thirds of the American seafood dollar is spent in food service establishments, and about one-third in retail sales for home consumption. With the shift to more dining out has come a major change in preferred fish products. Yesteryear's relatively few choices—cod, haddock, herring, mackerel, canned sardine, and whatever fresh fish might be available for the traditional Friday night seafood table—have given way to a veritable banquet of fresh and frozen seafood products. Today's top 10 favorites are canned tuna, shrimp, cod, pollock, flatfish, clam, catfish, salmon, crab, and scallop. Very telling of how the seafood industry has changed in just the last decade, five of these items are currently farm-raised or cultured in quantity: shrimp, salmon, catfish, clam, and scallop.

Some of this shift is related to new distribution patterns, with top-quality fish and shellfish available in the remotest corners of the nation. Farmed salmon, shrimp, and other aquaculture products are now offered at reasonable prices and are no longer luxury foods (although these cultured products have sometimes spurred price wars with wild-caught resources). Another factor is related to Americans' current dining-out trend: the majority of consumers are

CHESAPEAKE BAY'S FINEST
FRESH FISH DAILY
CAPTAIN WHITE
SEAFOOD CITY
SHRIMP & LOBSTER
JUMBO CRABS
COOKED CRABS
LIVE CRABS
CAPT. BEN'S FISH DOCK
MAIN ENTRANCE
SEAFOOD MARKET
CAPT. BEN'S FISH DOCK

TOP/BOTTOM: Some markets specializing in seafood are sophisticated and immense … while some sellers maintain a homey, simple approach. *Photos by Edward J. Pastula, NOAA Fisheries.*
INSET: Many people who say they "don't eat fish" make an exception for premium shellfish, like Alaska king crab. © *William B. Folsom Photography, Inc.*

happy to order seafood at restaurants and fast-food establishments, but often less eager to prepare it at home.

Some people, of course, aren't enthusiastic about seafood. The seafood industry spends lavishly to convince them otherwise and to devise dishes that appeal even to fussy children, understanding that people who don't eat seafood as children generally don't eat much of it as adults. Increased consumption will depend on overcoming some strongly held beliefs and misconceptions: fish is difficult to cook properly at home; seafood isn't as filling as meat or poultry; some favorite species are still expensive; special trips to the store for fresh seafood are inconvenient, or desired products aren't available; and fish may be contaminated by pollutants, toxins, and germs from careless food handlers.

The industry has made progress against these objections. More and more people who formerly didn't eat fish are now eating farm-raised fish, believing it's more wholesome than wild fish, since the fish farmer has greater control over his "catch." Other people look more for the "wild" taste of wild-caught fish—Alaska's salmon fisheries have very astutely made good marketing use of this preference. And public confidence in the safety of seafood is rising through broadened inspection, reliable brands, and quality flash-frozen products. But setbacks do occur as occasional outbreaks of diseased or contaminated products throw a scare into consumers who then refuse to buy any seafood.

Getting kids to eat more fish is still difficult. School cafeterias may have replaced the mysterious "tuna surprise" of years past with snappy fish sandwiches and fish-and-chips. However, seafood items still generally take a back seat to hamburgers and tacos. This could change, though, depending on the marketing ingenuity of such organizations as the National Fisheries Institute, and the many state and specialized seafood product marketing councils. One means for increasing youth fish consumption has been through U.S. Department of Agriculture programs that pay a better-than-market price on bulk quantities of underutilized species, which can be used for schools and the military.

Immigrant and other minority populations are a strong market for seafood

Some consumers, like this shopper at a Freeport, Long Island, market, like to select their dinner "on the fin." *Edward J. Pastula, NOAA Fisheries*

CAPTAIN D's
Captain D's SEAFOOD
OYSTE DINNER 5 49

RIGHT: Fast-food chains featuring inexpensive fried fish, shrimp, and clams are especially appealing to younger consumers. *William B. Folsom, NOAA Fisheries.* **BELOW:** Seafood specialty restaurants increasingly lure customers from establishments featuring meat and poultry. *© Edward J. Pastula, Reflective Imagery, Ltd.*

Red Lobster

Felix's
RESTAURANT
OYSTERS

New Orleans celebrates its immigrant past with ethnic seafood restaurants and cuisine. *Lauri Lawson, NOAA Fisheries*

products, especially people from coastal areas or countries with a tradition of high seafood consumption. Some Asian and Hispanic cultures make fresh fish and shellfish a common part of their diet; there are whole blocks of exotic seafood emporiums in the nation's coastal Chinatowns. Unlike the larger American pattern of consuming seafood primarily at restaurants, these populations eat much of their fish at home.

Both immigrant and native-born populations savor many of the same species, especially shrimp and crab, but respectable U.S. market shares are being claimed by tuna, salmon, lobster, rockfish, swordfish, oyster, perch, halibut, snapper, and grouper. New seafoods continually appear in markets and restaurants, in part as a response to changing consumer and dietary preferences. Chinese *dim sum* lunches feature the exotic periwinkle (a tiny mollusc), Thai restaurants offer savory squid, and Mexican cuisine presents countless octopus and shark dishes. More "traditional" American fare, including the cuisine of earlier immigrant groups, has attracted admirers of such shellfish delicacies as spiny lobster, softshell crab, and mussel, and the elegant lemonfish, shark, and dolphin fish. (Hawaiian partisans insist their mahi mahi is more flavorful and delicate than the Atlantic dolphin fish, but in fact they're the same species.)

Until fairly recently, shoppers purchased fish at specialized seafood markets, which remain important in the small business sector. Today the seafood counters and frozen food sections in supermarkets nationwide are filling a large part of this demand. Florida shark steaks are barbecued in a Colorado once devoted to beef steaks, and fresh-steamed lobsters grace the tables of Iowa pork producers.

In an effort to increase its share of every dollar spent on animal protein, the seafood industry has developed mouth-watering color advertisements and is giving away millions of seafood recipe cards to lure consumers to the seafood case. Clever fish logos and mottos abound, and fishermen themselves can be found hawking their products in market promotions. Of course, not every car sporting an "Eat oysters, love longer" bumper sticker belongs to a commercial fisherman, just as the sticker proclaiming "Even the worst day fishing is better than the best day working" isn't the exclusive provenance of an angler.

The introduction of new fish and shellfish products has especially been a boon to the food service industry. Fine "white linen" establishments tempt patrons with delicately sautéed monkfish fillets and barely seared fresh tuna steaks. Down the street, fish-and-chips emporiums tempt the casual diner, and sushi bars serve up glistening sea urchin roe and octopus slices to the more adventurous. Even surimi, the processed fish paste used in "artificial" crab and lobster products, is eagerly sought by salad bar patrons, and has found a solid niche on hospital and airline menus.

The incomparable sushi platter—one of Japan's most cherished gifts to the world. © *William B. Folsom Photography, Inc.*

Upscale markets like this one in McLean, Virginia, offer a wide choice of premium seafood. *William B. Folsom, NOAA Fisheries*

SEAFOOD SAFETY

Public confidence in the safety of fish products is vital to the health of the industry. Even a mild "fish kill" having no effect on humans can ruin local seafood and tourist economies. Considerable research on seafood pathogens and toxins has come about specifically at the demand of industry leaders eager to halt environmental conditions that affect fishery resources—and, sometimes, human health—such as red tides, oyster and clam bed contamination, and other pathogenic eruptions. In some cases, media reports of these events are blown out of proportion, prompting fishermen, dealers, restaurants, and markets to plead for more accurate reporting of seafood-related risks.

Small seafood shops, like this one in Washington, D.C., develop clever marketing strategies to briskly move their seasonal offerings. *Edward J. Pastula, NOAA Fisheries*

Seafood processing is unique among food services because it involves a wide range of species and products, each with its own contamination and spoilage risks. Tainted fish and shellfish can result from water-borne bacteria, viruses, pesticides and other chemicals, naturally occurring marine toxins, improper handling, and even adulteration to hide spoilage. But except for raw shellfish, the incidence of illness resulting from eating seafood is far lower than for poultry or beef. The risk of seafood-borne sickness (discounting raw shellfish) is one in five million servings, while the risk of illness from eating chicken is one in 25,000 servings.

Federal seafood processing is overseen jointly by the Food and Drug Administration (FDA), the Environmental Protection Agency (EPA), and the Department of Commerce's National Marine Fisheries Service (NMFS). This cooperative oversight relies on mandatory inspections of seafood plants by FDA and on voluntary inspection and certification services by NMFS.

Inspection of meat products is mostly visual, with the inspector scrutinizing carcasses and tissues for obvious signs of contamination. Because most contamination of fish products can't be seen, the federal government, at the urging of the seafood industry, established a new risk assessment system that identifies critical points of the production process that are prone to contamination or spoilage. Under this Hazard Analysis Critical Control Points (HACCP) program, domestic processors, foreign processors shipping to the United States, at-sea processors, and seafood distributors are required to develop and implement HACCP plans.

The HACCP system relies on stringent documentation—accountability—rather than intensive federal inspection of the product itself. Very careful records are made of the various safety indicators—temperature, humidity, etc.—at each control point. If indicator values fall outside the plan's acceptable levels, the processor or harvester must take immediate corrective action at that control point. For example, if a filleting machine breaks down while fish are being processed, the machine must be fixed immediately. During this repair, the plant may fillet by hand using the same sanitary standards. The responsible plant personnel must promptly fill out a complete report on the incident.

Full implementation of HACCP is expected to have significant benefits for the

An army officer inspects products destined for the World War II troops at a Seattle fish processing plant. *Scientific Publications Unit, NOAA Fisheries*

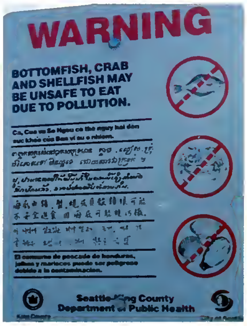
LEFT: A trained inspector at a Virginia scallop plant examines both the catch and its paper trail. *Edward J. Pastula, NOAA Fisheries.* **RIGHT:** These packages of raw seafood at a Baltimore plant bear seals certifying they were packed under an approved HACCP program. *Edward J. Pastula, NOAA Fisheries*

nation, saving millions of dollars through fewer instances of seafood-borne illness. Public confidence in seafood is also likely to lead to a healthier national diet, with fewer deaths from cardiovascular disease and associated savings to the nation's health bill. The new program has a weak spot: seafood preparation in the home. Thus, the industry, extension advisory services, and federal agencies have intensified efforts to educate consumers on how to properly handle and cook seafood at home.

Another seafood safety program is the state–federal Interstate Shellfish Sanitation Conference, which ensures that oysters and clams are not harvested commercially in contaminated waters. Inspectors monitor oyster and clam beds for bacteria and viruses. When "action levels" are reached, warning signs are posted prohibiting harvest. This system requires that a tag of origin accompany every bag or bushel of oysters or clams all the way from the harvest area to the point of sale.

Still another check comes from FDA guidelines on maximum allowable levels of mercury and other potentially toxic metals and chemical compounds in fish products and on the use of excessive amounts of additives, such as sodium tripolyphosphate to plump up the meats of shrimp and other species. The 1960s and 1970s saw several scares worldwide related to toxic compounds in large predator species—striped bass, swordfish, tuna, and shark—following industrial accidents or chemical discharge into coastal waters. Although fewer such contaminants enter the food web today, some experts still advise that pregnant and nursing women limit their consumption of tuna, swordfish, and sharks to once a month, to be on the safe side.

Unfortunately, even rigorous regulations can't protect everyone against tainted seafood. For one thing, commercial fish product inspection isn't mandatory. For another, there are no programs to inspect fish and shellfish taken by the recreational or subsistence fishermen landing their catch at literally thousands of beaches and docks. This situation becomes most worrisome where contaminated fish and shellfish may be consumed by especially vulnerable groups—young children, pregnant or nursing women, older adults, and people with compromised immune systems.


WARNING
BOTTOMFISH, CRAB AND SHELLFISH MAY BE UNSAFE TO EAT DUE TO POLLUTION.
Seattle-King County Department of Public Health

LEFT: Sign of the times: a seven-language warning of polluted waters to the multicultural residents of Seattle. © *William B. Folsom Photography, Inc.*

RIGHT: Origin tags are applied to every bag of cultured blue point oysters leaving this Norwalk, Connecticut, plant. *William B. Folsom, NOAA Fisheries*

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2

INSPECTION: EVERYONE'S CONCERN

Harvesters, processors, government agencies, and consumers have at least one concern in common when it comes to seafood: product safety. Commercial fisheries have therefore developed elaborate inspection systems and processes that check seafood products on the deck, at the dock, in the plant, and at the counter. A mere handful of these processes is shown here.

6

5

1 Labeled packages are boxed and inspected at a Baltimore plant before shipment to local markets. *Edward J. Pastula, NOAA Fisheries.* **2** A Baltimore worker affixes a government-authorized inspection sticker to packages destined for the seafood counter. *Edward J. Pastula, NOAA Fisheries.* **3** Randomly selected albacore from a just-unloaded batch are examined by a staff biologist at a Puerto Rico tuna cannery. *William B. Folsom, NOAA Fisheries.* **4** A federal official watches as croaker are headed and gutted for processing under a Baltimore plant's approved HACCP plan. *Edward J. Pastula, NOAA Fisheries.* **5** Bluefish fresh off the boat are given a temperature check as part of a Baltimore plant's HACCP inspection plan. *Edward J. Pastula, NOAA Fisheries.* **6** A state inspector examines scallop meats at a plant in Seaford, Virginia, for compliance with health and safety laws. *Edward J. Pastula, NOAA Fisheries.*

3

4

U.S. GRADE A
FISHERY PRODUCTS INSPECTION SERVICES
OF THE
U.S. DEPARTMENT OF
Quality
SINCE 1968
INSPECTED SEAFOOD
TO YOUR HEALTH
Food Safety at Home

ABOVE: Though some nearshore pollution is obvious, unseen contaminants may be far more deadly to fish and shellfish. **LEFT:** Many of the documents discussing seafood safety come from those with a vested interest: the seafood industry. **RIGHT:** The catch of anglers like this woman in Beaufort, South Carolina, is not subject to inspection. *Photos: William B. Folsom, NOAA Fisheries*

Another problem is increased consumption of raw seafood—oyster on the half shell, sushi, sashimi, and ceviche—which may harbor viruses, bacteria, parasites, or other pathogens. Although such delicacies pose only a slight risk to most people, some segments of the population are more at risk, especially those with HIV infection and other immune disorders, people who use steroids for long periods to treat asthma or arthritis, and people with liver disease and diabetes. The industry, along with state and federal health officials, issues frequent warnings to these groups about eating raw seafood.

Another danger occurs in some localized tropical areas. "Ciguaterra" toxin affects humans who consume barracuda, Spanish hogfish, and other predators from certain locations. The toxin accumulates in small fish feeding on naturally occurring algal blooms, but neither these fish nor their predators are harmed. Dining on these predators is a different story, however, as the particularly nasty neurological toxin causes dizziness, numbness, paralysis, and even death. Most ciguaterra poisoning can be avoided merely by not eating these predators in areas known to be affected, but few fishermen and their families have totally escaped ciguaterra, and tourists' vacations have occasionally been ruined by this frightening malady.

The industry must also deal with headaches under the general rubric of quality. A few dealers, and even some harvesters, have deliberately mislabeled or substituted lower-value species, camouflaged poor-quality products by using bleach or other chemicals, or bypassed required inspections by selling outside regulated market channels. The seafood industry, with everything to lose by such illegal tactics, has itself sought self-policing measures and has urged the passage of regulations to prevent seafood fraud.

THE ERA OF MANAGEMENT

In the United States, fisheries management generally means government regulation. In common with other types of natural resource management, fisheries regulation tries to answer two questions: How many animals can be removed, or harvested on a sustainable basis? And who gets them?

Many believe that true management of America's fisheries at the federal level began only recently, with the 1976 passage of the Fishery Conservation and Management Act. Yet management of the nation's waters was quite extensive for a long time, perhaps even before the arrival of European explorers. Unfortunately, archived accounts of colonial fishing practices don't include much about early Native American efforts to manage and distribute fishery resources.

English and Dutch colonists were already familiar with government actions

THEY THAT GO
DOWN TO THE SEA
IN SHIPS
1623 - 1923

This famous Gloucester, Massachusetts, memorial is a somber reminder of the Atlantic's deadly toll on fishermen. *Nance S. Trueworthy, NOAA Fisheries*

to regulate catches. To protect English waters from further encroachment by the expanding Dutch fleet in the early 17th century (and to restrict fishing to those already harvesting fish and shellfish), the Crown established a council to regulate nearshore harvests. Like the present-day Fishery Management Councils, these bodies were composed of fishermen and others appointed by the government, and their recommendations were intended to determine who could fish, when they could fish, and for what species.

These early efforts dispel the widespread fiction that only modern societies recognize the finite nature of the sea's resources. In earlier fishing eras, observations about depleted stocks pertained primarily to nearshore waters, but they're extraordinarily perceptive. The first U.S. Commissioner of Fish and Fisheries, Spencer F. Baird, noted in 1872, perhaps simplistically:

> "… the exhaustion of a local fishery is not like dipping water out of a bucket, where the vacancy is immediately filled from the surrounding body; but it is more like taking lard out of a keg, where there is a space left that does not become occupied by anything else."

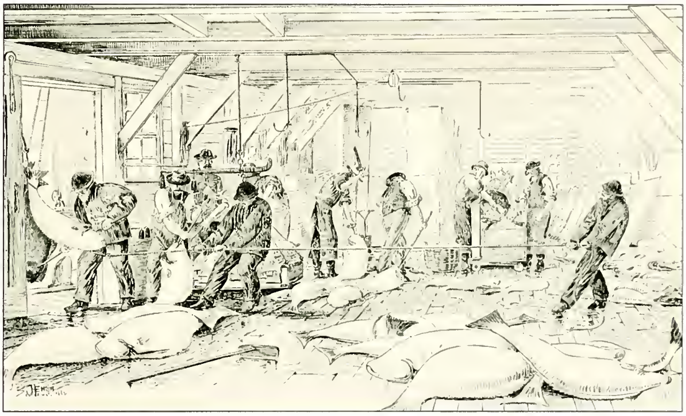
Many fishermen of the period adamantly disputed Mr. Baird's conclusions, believing that migratory stocks simply couldn't be diminished by overfishing.

Specific regulatory regimes are discussed in the context of this book's regional sections. It's helpful here to offer a general discussion of American fisheries management.

The most contentious issue among fishermen today is management. But for almost a century following the nation's founding, government had little involvement in the conduct of its fisheries. In spite of fishing's prominence in early America, its practitioners generally shared a popular distaste for government involvement in any aspect of commerce. Government leaders had a different view, seeing a need for federal and state involvement. Secretary of State Thomas Jefferson noted in 1791, in the nation's first comprehensive fisheries report to the U.S. Congress, that the Revolutionary War had devastated American fisheries, and he cited the importance of fishing to trade with Europe. John Quincy Adams, too, realized fishing's importance, arguing in 1822 for protection of U.S. fishing rights during negotiations for the Treaty of Ghent.

However, no official government involvement was authorized until 1871, when the depletion of New England's ocean and lake fish led Congress to create the U.S. Commission on Fisheries. Its charge was quite narrow: study the reasons for the apparent decline, and recommend solutions. Scarcely a year later, a new

TOP: Nineteenth-century New Englanders were still able to take the Atlantic halibut that are today severely overfished. *Drawings by H.W. Elliott and Captain J.W. Collins. The Fisheries and Fishery Industries of the United States, NOAA Fisheries.* **BOTTOM:** Thousands upon thousands of sport divers exert a strong voice for conservation. *© William B. Folsom Photography, Inc.*



Most early 20th-century vessels fished locally and didn't urge greater national control over offshore waters. *Courtesy of* PACIFIC FISHING *magazine*

task—fish culture—was added as a result of interest in artificial propagation to rebuild stocks of decimated Atlantic salmon and shad. The new Commission also helped spur the establishment of state fishery agencies, which increased from 11 in 1871 to 26 by 1877, primarily to advance fish culture. The federal commission did something more. It defined the government's role for the next 100 years: research and marketing to support commercial fisheries operations and development.

The Commission's rebirth in 1903 as the Bureau of Fisheries didn't change this charge, although its operations were expanded into the Southeast, Gulf of Mexico, and Pacific Coast. By the end of World War II, the government had expanded its role into promoting commercial fishing and wider use of fish, including food production for the nation's troops.

The impetus for real change after World War II, though, was a combination of technological advances and the country's determination to control the extraction of natural resources—both animal and mineral—on its entire continental shelf. Since the end of the war, foreign fleets had taken many of these resources, working just three miles outside of America's jurisdiction. Americans themselves roamed the high seas under policies heartily supported by Congress. Most nations with an ocean coast had already extended their jurisdiction to Exclusive Economic Zones (EEZs) that included waters extending 200 miles from shore. In essence, nations had sole authority over the living resources in their EEZs, which account for the vast majority of the world's fish stocks. The United States declared its own EEZ in 1983 following the passage of the Fishery Conservation and Management Act.

The 1970s were the high-water mark for environmental legislation. That decade saw the Marine Mammal Protection Act, Endangered Species Act, Water Pollution Control Act (Clean Water Act), and National Environmental Policy Act. Congress created the National Oceanic and Atmospheric Administration and placed within it the new National Marine Fisheries Service, created from the old Bureau of Commercial Fisheries and parts of the U.S. Fish and Wildlife Service that dealt with recreational fishing.

By the early 1970s, it had become obvious that American fishermen, with their generally smaller vessels and gear, were losing out badly to the giant foreign trawlers working massive nets and lines just a few miles offshore. The Fishery Conservation and Management Act was the nation's response. Successfully promoted by

Surimi—the product that painted a new picture of American fisheries. © *William B. Folsom Photography, Inc.*

Washington's powerful Senator Warren Magnuson, the Act had several almost immediate results: a dramatic reconstruction and expansion of some parts of the American fishing fleet through federal loans and tax advantages; the formation of joint ventures under which fish caught by U.S. vessels were directly sold to foreign ships for processing; and the exploration for, and exploitation of, the nation's immense unexploited fishery stocks.

The Act was a remarkable construction. It established eight Regional Fishery Management Councils to develop plans for fisheries that relied on stocks living primarily in federal waters. The majority of Council members were to be informed citizens—usually people involved in fishing—nominated by governors of coastal states and appointed by the Secretary of Commerce, who had the responsibility for preparing marine fisheries management plans. Council meetings would also have participation by federal and state officials and the Interstate Marine Fisheries Commissions. Business would be conducted openly, meetings would be announced in advance, and operating rules and procedures would be written out. Most important, the voice of the public, including fishermen, would be heard through hearings, written comment, published records, and participation on advisory committees and panels.

That was the intent and, indeed, that's essentially what happened. There have been numerous amendments, more along the nature of fine-tuning than of radical change, and usually to address new statutes and issues not dreamed of in 1976. During periods of the Act's reauthorization by Congress (every four to six years), constituents of all kinds bombard both legislators and the Department of Commerce with preferences and opinions, and there is considerable wrangling in both branches about how to accommodate these divergent needs in a meaningful compromise.

The Act requires that each Council represent equitably the various users and interests concerned with the region's fisheries resources. Thus, Councils in regions with heavy recreational interests look different from those in regions with primarily commercial users or those with indigenous or subsistence fisheries. The particular mix of interests represented on a Council is of intense concern to stakeholders and can make a difference when it's time to vote on an action. Indeed, a few historic management failures can be attributed at least in part to members' self-serving voting patterns.

Without a doubt, the single greatest area of conflict on Councils is allocation: dividing the fishery pie. Almost all management decisions center on either conservation or allocations among users. At times, though, cries for "conservation" are actually attempts to discredit rivals or limit their catch. Strong emotions erupt at Council meetings and public hearings. Charges, countercharges, grudges, and stern faces are the usual climate of Council meetings, and many new Council members have been dismayed to find themselves the new target of former allies. For all participants, attending a Council meeting can be exhausting and aggravating—but seldom boring.

The public often has a mistaken impression of what the Councils and government can do and how fast they can do it. The Act contains exacting national standards as the yardstick for decisions: regulations must provide for fair and equitable allocation, use science as the basis for decisions, and value conservation above utilization. The regulatory process for fisheries, as for U.S. regulations in general, is fixed, complex, and seemingly arcane. This isn't an

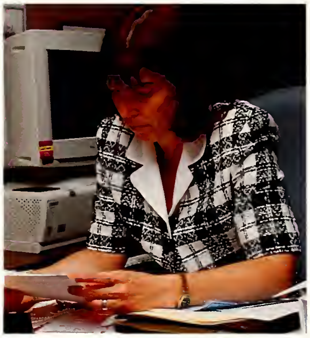
A *Hand* IN MANAGEMENT

Julius Collins is one of modern fisheries management's most prominent faces. Owner and operator of several large shrimp trawlers based in Brownsville, Texas, Julius was for many years a member of the Gulf of Mexico Fishery Management Council, and has long been a tireless advocate for industry involvement in government regulatory processes.

Commercial fishermen from dozens of fisheries have served alongside anglers, conservationists, and academics on the nation's eight regional Councils, assessing the state of U.S. fisheries and recommending measures to conserve and manage them. They often take more than a little heat from friends and family when their Council votes go against the sentiment back home.

But Council membership is not the only place one finds activists from the fishing community, like Julius. Each Council meeting and hearing sees a large and diverse constituency from both commercial and recreational fisheries, closely following scientific and economic assessments of the resources and impatient to state their views on proposed management measures. Stakeholders and concerned citizens also champion their positions at hearings held by other federal, state, and tribal resource management agencies and the Interstate Fisheries Commissions, and they regularly demand to be heard before congressional and state legislative committees. These energetic debates, often by well-informed, paid advocates representing just about every type of fishing in the country, constitute one of the most dynamic and vigorous democratic processes in America.

Julius Collins, Brownsville, Texas (William B. Folsom, NOAA Fisheries)



LEFT: The Magnuson–Stevens Fishery Conservation and Management Act of 1996 requires measures to prevent overfishing. *William B. Folsom, NOAA Fisheries.* **TOP RIGHT:** Regional Council meetings are often a lively interplay of government, stakeholders, and concerned citizens. *Lauri Lawson, NOAA Fisheries.* **CENTER:** Members of the fishing community react to a proposed conservation measure to cut the number of allowable fishing days. *Lauri Lawson, NOAA Fisheries.* **BOTTOM RIGHT:** Fisheries managers, like NOAA's Penny Dalton, try to balance conservation and utilization needs. *William B. Folsom, NOAA Fisheries*

unfortunate bureaucratic effect; it was designed that way to comply with Constitutional principles of equal treatment and due process and to protect other rights. This isn't always readily apparent to constituents, in part because officials sometimes fail to explain the relationship between the regulatory process and the Constitutional protections it ensures, as well as other important environmental and administrative statutes that interact with fisheries activities.

The management process itself is a series of hierarchical approvals, interspersed with public comment. Management measures usually take from six months to a year to implement from the time they're proposed. Minor adjustments, such as seasonal openings or closings, can be implemented in a few weeks or months, and emergency actions can also be taken quickly if fish stocks or the industry would be seriously damaged by the normal lengthy procedure.

Hundreds of management actions from all over the country may be implemented each year. Most actions are routine, such as seasonal openings and closings, annual quotas, and gear modifications. A growing number have such long-term impacts that they require extensive scrutiny by many scientists, economists, and lawyers and several public hearings before they can be implemented. Especially complex or controversial management measures—such as quotas that assign shares of the available harvest each year to individual fishermen—are guaranteed to take years of deliberation. Their provisional approval by a Council begins a daunting cycle of public hearings and countless plan revisions—sometimes only to wither on the vine of intractable politicking.

Boats stacked in a Long Island boatyard await the openings of seasons for nearshore New York fish. *Edward J. Pastula, NOAA Fisheries*

Although federal fisheries management is a quite recent affair, coastal states have had extensive experience in managing their territorial waters (usually, from shore out to three miles). In fact, state universities and agencies perform much of the fisheries science, regulation, and enforcement. Depending on a state's relative wealth, the importance of fishing to commerce or recreation, the value of available species, and whether special conditions—as with Alaska's integrated

Alaska manages its own nearshore fisheries, such as these Copper River salmon scoop-net operations. © *William B. Folsom Photography, Inc.*

state–federal management—state management systems can be very large and complex. In some states, fisheries management and enforcement authority is vested in a designated agency. In other states, fisheries commissions under the governor's authority make management decisions, leaving science and enforcement to a state agency. And some states have a combination of these approaches.

Whatever the system, though, all coastal states have close ties to federal agencies that provide grants for research and management. Aside from funding, federal, state, territorial, and sometimes tribal governments exercise a great deal of control over the lives and activities of those who fish or raise fish, buy or sell seafood, transport marine products, or provide marine services. State and federal departments of agriculture, environmental quality, transportation, treasury, labor, food and drugs, Indian affairs, and other agencies (not the least of which is taxation) also have a substantial involvement in fisheries. And as in other sectors of American life, this means mountains of paperwork flowing between users and government for permits, licenses, reports, logbooks, vouchers, certificates, and receipts.

This plurality of management systems, while arguably necessary, sometimes results in confusion. State and federal fishing regulations for both commercial and recreational fishermen may be inconsistent in spite of attempts at uniformity. Some sizes or species of fish legally caught in one state's waters (or in a neighboring country's waters) may not be legally taken in federal waters, making enforcement problematic. Some species can be taken within one state, but not sold or even transported to states with different laws. Species designated as game fish in one state or region may have no such status in neighbor states, and can be sold commercially there. And so on.

Some progress has been made to harmonize regulations, though. States, territories, and Native American tribes have agreements with the federal government, and often with neighboring states, for cooperative law enforcement, management planning, and data collection. In addition to their Council seat, most states are members of the Atlantic States, the Pacific States, or the Gulf of Mexico Marine Fisheries Commission (the U.S. territories, Hawaii, and Alaska aren't represented on these Commissions). Chartered by Congress as a forum for the exchange of scientific information, enforcement coordination, and cooperative management planning, the Commissions have served as one of the major communications routes for state and federal governments and the fishing industry since the first one was established in 1942.

Only the Atlantic States Commission has any regulatory authority: the 1984 Atlantic Striped Bass Conservation Act and the 1993 Atlantic Coastal Fisheries Cooperative Management Act authorized

LEFT: State officials, such as this Delaware fish and wildlife officer in Lewes, have the largest role in fisheries enforcement. *William B. Folsom, NOAA Fisheries.*
RIGHT: Like hundreds of nearshore species, Hawaii's yellowstripe goatfish are managed by the state. © *Brandon D. Cole*

DELAWARE D
FISH AND WI
ENFORCE

LEFT: A Mississippi fisheries agent checks required documentation at a Pascagoula bait shop. *Lauri Lawson, NOAA Fisheries.* **RIGHT:** This U.S.–Morocco fisheries meeting is one of many each year for sharing information and management needs. *William B. Folsom, NOAA Fisheries*

Scientists remove sea turtle eggs from a Mexican beach to pen-rear the endangered Kemp's ridley. *David Bowman, U.S. Fish & Wildlife Service/NOAA Scientific Publications Unit*

the Commission, in conjunction with the Secretary of Commerce, to regulate fisheries occurring primarily in coastal waters of the eastern states. This Commission has the authority to force closure of fisheries not in compliance with its fishery management plans. The very real threat of federally enforced action has, so far, been sufficient to coax recalcitrant states into compliance.

As a result of agreements negotiated many years ago between Native American tribes and the U.S. government, recent Supreme Court decisions upholding those treaties, and state and federal legislation, tribes of the Pacific Coast currently play a significant role in managing fisheries. Their interactions are detailed in this book's chapter on Pacific fisheries.

Numerous valuable species—such as tuna, swordfish, salmon, cod, and pollock—move among the waters of many countries, including America. Some of our nation's earliest international conflicts arose over rights to these migratory stocks, and many disputes continue to this day. Under the authority of the U.S. Department of State, America has entered into many treaties and international agreements in a sometimes futile effort to equitably apportion these international stocks. For many high-value stocks, especially those demanded by both commercial and recreational interests, the squabbling seems interminable.

Various conventions among fishing nations have led to permanent commissions that make annual recommendations on allowable harvest levels and national apportionments. Where stocks are healthy, the fishing is relatively harmonious, with member nations abiding by the recommended regimes. This is currently the case with the Inter-American Tropical Tuna Commission's management of Eastern Tropical Pacific tunas. Where resources are heavily overfished, as with Atlantic bluefin tuna stocks, effective management is often crippled by international disagreements. Differences of opinion between competing American fishing interests—and sometimes conservation interests—also can prevent achieving a unified negotiating position.

The set of "teeth" in the management mouth, of course, is law enforcement. Most fishermen only occasionally see fishery managers and scientists, usually in the setting of a management meeting or public hearing. But enforcement officers are much more familiar as a result of their presence on the dock and, sometimes, on the water. Because of the vast areas fished by U.S. vessels and the enormous number of regulations, fisheries enforcement is through a rather creative alliance of state, federal, territorial, and tribal law enforcement agencies.

At-sea policing in federal waters is primarily through U.S. Coast Guard ship and aircraft surveillance, and by inspection boardings of fishing boats, with assistance from National Marine Fisheries Service enforcement agents. Dockside and in nearshore waters, an alliance of agents and uniformed officers of the National Marine Fisheries Service, coastal states and territories, and Native American tribes enforce literally thousands of fisheries laws. In addition to issuing citations, officers investigate fraud and illegal fishing and conduct public education programs to preventing transgressions in the first place. Many fishermen are bewildered by, or simply unaware of, the flood of regulations—fishing, vessel safety, and environmental—with which they must comply. Frequently, officers don't issue formal citations, but merely give warnings and provide information about current regulations. Wide-scale publicity about wrongdoing, and the sometimes hefty fines and sanctions resulting from egregious offenses, are fairly effective deterrents to most would-be lawbreakers.

When a citation is issued, it must be resolved through a formal adjudication system. Federally issued Notices of Violation and Assessment are usually handled through a civil administrative process in which the cited individual may pay the stated civil penalty, negotiate for a smaller penalty, or dispute the citation before a federal administrative law judge. Some actions, however, such as vessel and fish forfeitures, are heard in civil judicial courts, and breaking a federal criminal statute (for example, assault on an officer or reckless endangerment) may land the offender in a federal prison. State-issued citations are generally treated as either civil violations or minor crimes and are resolved in state or county courts. Tribal courts adjudicate only fisheries violations occurring on reservation waters by their own members. Fishing fines are generally rather modest. However, penalties may involve substantial fines; prohibitions on any further fishing; confiscation of the vessel, gear, and catch; or, in a few cases, all of these.

TOP: A Virgin Islands fisheries officer visits with workers at a dockside filleting operation in Charlotte Amalie, St. Thomas. *William B. Folsom, NOAA Fisheries.* **BOTTOM LEFT:** Federal fisheries officers and Coast Guardsmen conduct a joint inspection of a Northwest salmon troller's catch. © *Brad Matsen.* **BOTTOM RIGHT:** A federal enforcement officer discusses closed areas with the crew of a shrimp boat in Bayou La Batre, Alabama. *William B. Folsom, NOAA Fisheries*

THE SCIENCE BEHIND MANAGEMENT

Both state and federal fisheries statutes specifically require that management decisions be made on the basis of science—usually, the best scientific information available. Without good information, managers can't determine how many fish, and of what size or sex, may be taken without jeopardizing future harvests, or how the catch should be apportioned fairly and equitably. Fisheries science isn't cheap, requiring the costly collection of large amounts of data. And even where the data are sufficient—and this is the case for many resources—fisheries interests have sometimes halted proposed management measures simply by disputing minor points of interpretation of these data. Entire regulatory regimes have also been derailed by clever challenges of scientists' credentials or insistence on collecting sometimes repetitive data.

Scientific information used for fisheries management comes from several disciplines: biology, ecology, economics, and sociology. For some American fisheries, as in New England, the biological data bases are the best in the world, with some more than 100 years old. For some other resources, however, information on their biological status and utilization level may be quite sparse.

The criticism about specific conclusions sometimes obscures the real significance of these decisions, upon which thousands of jobs depend. If sound data are the foundation of effective management, then the superstructure consists of models to predict what will happen under alternative management strategies. The mention of the word "model," with its implication of complex statistics and uncertainty, is often enough to glaze the eyes of fishermen. Biological models address many questions, especially the amounts of fish that can be taken without destroying the stock and the costs and benefits of alternative management strategies. Economic models, on the other hand, examine the value of those catches and the expected economic and social impacts of management measures. Biologists want to identify fishing strategies that provide the greatest yields over an almost infinite time frame without damaging the stocks, and economists want to identify the costs and benefits of alternative fishing strategies.

Information for these models comes from many sources. Research cruises record the abundance, distribution, size, and sex of target and associated species and at the same time collect fish eggs and larvae and environmental data. Such information is termed "fishery-independent," since it doesn't come from fishermen's catches. "Fishery-dependent" information, on the other hand, comes from dockside catch records, fishermen's logs, and trained observers recording catches aboard commercial fishing vessels. Still other information comes from laboratory or field studies of species'

LEFT: These Seattle scientists are federal workers, but states, universities, and other organizations also conduct fisheries research. *William B. Folsom, NOAA Fisheries.* **TOP RIGHT:** The Yakama (shown here) and other Northwest tribes have their own scientists to help assess the stocks they fish. © *Chuck Williams, Columbia River Inter-Tribal Fish Commission.* **BOTTOM RIGHT:** A federal fisheries scientist examines a research trawl catch off Oregon to assess Pacific coast crab stocks. © *Allen M. Shimada*

State fish and game researchers set up a base camp at Togiak Bay, Alaska, to study regional fish stocks. © *Allen M. Shimada*

age, growth, food habits, reproduction, migrations, behavior, disease and parasites, and ecology.

Fishermen in some regions are often puzzled about research methods. Shipboard surveys, especially, are an enigma because scientists appear uninterested in sampling where fishermen "know" the fish to be abundant and, instead, seem to plot sampling stations without regard to known fish concentrations. In reality, though, these surveys are meticulously designed to compare fish occurrences in an area over several years. Fisheries scientists are generally confident about their survey methods, even if they aren't always successful in explaining them to nonscientists.

Dockside sampling, too, tends to mystify fishermen. While some fishermen have a good grounding in statistics, many are untrained in statistical analysis and find it difficult to believe that sampling only a few sites among many where fish are landed could yield valid information about the entire fishery. Not too many years ago, fishermen sometimes deliberately stonewalled catch sampling, in the belief that the lack of information about dwindling resources would preclude regulations that might reduce their income. Today, though, when managers tend to curtail harvests if the data aren't good, fishermen are more inclined to insist on collecting good information. Indeed, in some fisheries, commercial and recreational fishermen are directly involved in the research, through carefully designed and monitored data collection programs.

A perpetually contentious research area is observer programs, where trained government or contracted workers onboard fishing vessels record a variety of data, including bycatch. Such work is demanding and costly, but perhaps one day will be replaced by technological innovations that can reliably identify, count, and record the species taken, and transmit these data to shoreside analysts. Given the explosion of technologies—computers, artificial intelligence systems, satellites and other remote-sensing devices—that have already extended scientists' intellectual reach, such systems seem likely.

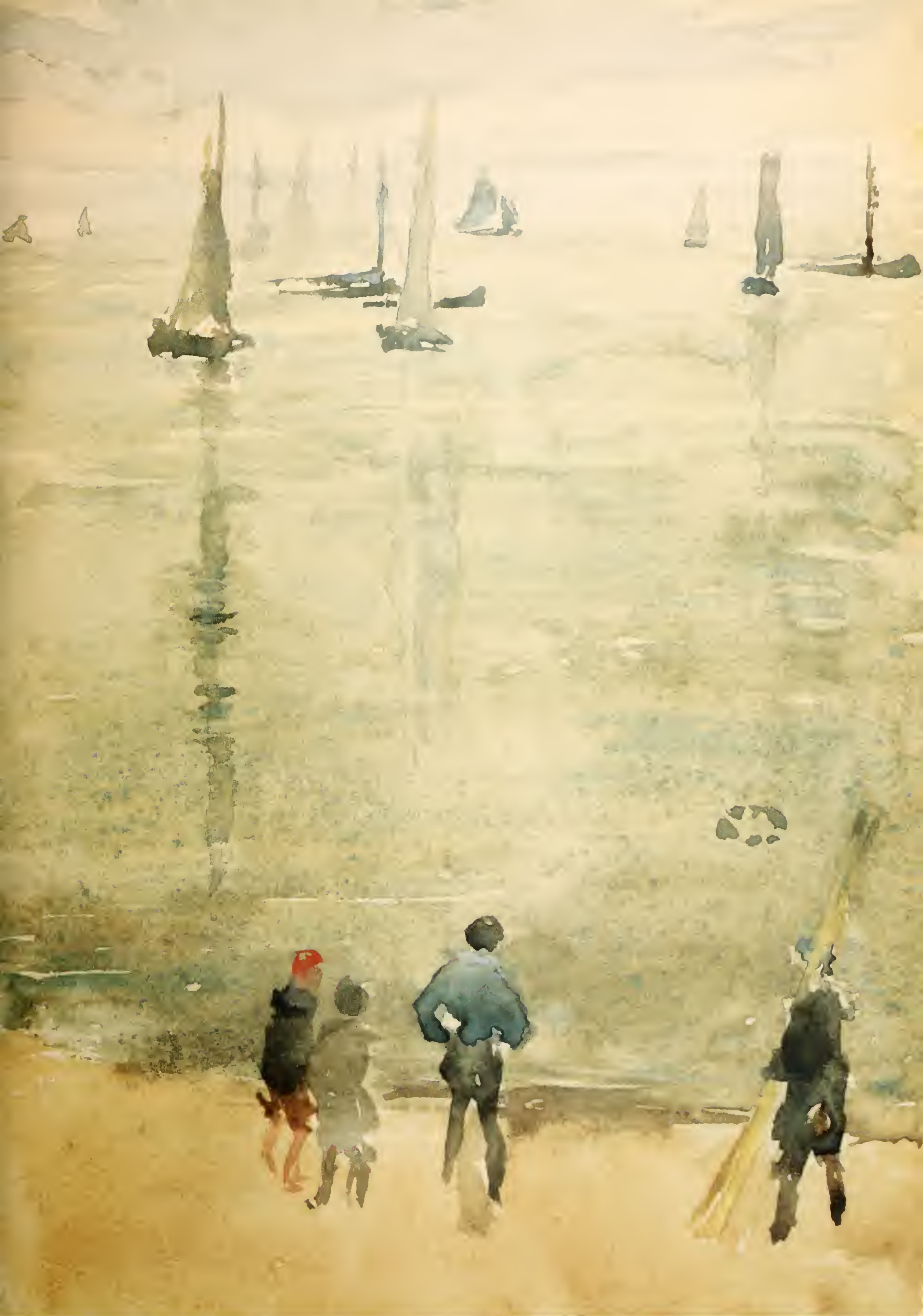
But it is probably the nature of science itself—questioning, analyzing, challenging—that creates conflict and confusion in fisheries management. Fisheries scientists are human, and it is inevitable that different analyses of the same data will produce varying interpretations and predictions.

LEFT: A gear researcher observes a shrimp-net turtle excluder device as part of a program to reduce turtle captures. *Mississippi Laboratories, NOAA Fisheries.*
RIGHT: NOAA data buoys await deployment in icy Alaska waters to provide information on ocean and climate conditions. © *Allen M. Shimada*

James McNeil Whistler
Detail from *Return of the Fishing Boats*
Gift of Mr. and Mrs. Paul Mellon, in Honor of the 50th Anniversary of the National Gallery of Art
Photograph 1998 © Board of Trustees, National Gallery of Art, Washington

3

A HARD LIVING



The major—and obvious—distinction between commercial and recreational fishermen is that the former rely on fishing for part or all of their income. This chapter looks at their livelihood, the business of fishing.

THE SCALE OF FISHING

Fishing has always been an arduous occupation. Like other food-production work, it's far more complex today than in former times. Coastal area residents recognize the shrimp trawlers, lobster boats, and salmon seiners that populate their harbors, but most people have never seen even one of the gigantic factory ships or freezer-trawlers that garner so much media attention. As it happens, the vast majority of American fishermen work in small operations, often only one or two per boat. This doesn't necessarily mean these people are "small-scale" fishermen. A look at the fishing life might best begin, then, with what is meant by "small-scale" and "large-scale" fisheries.

"Small-scale" most appropriately describes fisheries that have a relatively small individual commitment of capital and a low level of production. Though this commitment may seem weak compared to big operations, it may actually represent a substantial portion of a family's savings or income. Some of these are termed "subsistence fishermen"—that is, they and their families directly consume most of what they catch, although they may trade or barter a few fish. Small-scale operations also include many others: the people who *do* sell their fish, artisanal fishers (those who make much of their gear or boats by hand), indigenous groups, and traditional "village" fishermen. At the global level, there are some common attributes: these groups generally have little ability to influence markets, are poorly represented in public policymaking, and are often helpless in safeguarding their own environment from the activities of other industries and interests.

ABOVE: Small-scale fishermen in Crashboat, Puerto Rico, sell their catch—snapper, mackerel, and dolphin fish—locally. *William B. Folsom, NOAA Fisheries.* **BELOW:** Many Alaska Native American communities, such as Unalakleet, depend on salmon harvests for subsistence. *Scientific Publications Unit, NOAA Fisheries*

Artisanal and subsistence fishing isn't exclusive to Third World or island nations. It is also practiced by a great many Native Americans in Alaska and the Pacific Northwest; indigenous people of Hawaii, Samoa, Guam, and the Northern Marianas; small villages in the U.S. Caribbean; and many low-income individuals throughout the country.

Many small-scale commercial fisheries in the United States have a long history, and have managed to keep alive their rich

FACING PAGE: Icy crabber. © *Karen Ducey*

Florida's sponge fleet is a relic of the past—the Tarpon Springs fleet now fishes mostly for shrimp, not sponges. © *Index Stock/Timothy O'Keefe*

cultural traditions. Alaska has its Eskimo whalers and seal hunters; the Pacific Northwest, its salmon fishers; the Chesapeake, its watermen; and New England, its lobstermen. A few fishing subcultures, such as Florida's Greek sponge divers, have largely died out, and new groups—frequently immigrant—have sprouted up to give new life to coastal fishing communities, often evolving from small-scale units to powerful, large-scale units. For example, the Vietnamese fishing community has become an industrious force in recent decades, shrimping in the Gulf of Mexico, longlining in Hawaii for tuna and swordfish, setting lines and pots for groundfish on the Pacific Coast, and crabbing in Texas and California.

Small-scale fishing is often more efficient than large-scale fishing. In addition to relatively modest outlays for capital equipment—boats, engines, and gear—expenses for fuel and labor for the day's catch are generally far less than for heavily industrialized vessels. Small-scale fishing accounts for more of the locally consumed catch, but these enterprises often lose out to large-scale operations, with their high rates of exploitation, modern technology, and dynamic marketing paths.

Large-scale fisheries almost always have far greater catches and, usually, greater profits. However, they carry unfortunate consequences for their heavy capital investment: longer hours, unstable employment, greater economic risk, and, often, disintegration of

LEFT: A workshop at the Maine Maritime Museum in Bath crafts small dories, much as they were made a hundred years ago. © *William B. Folsom Photography, Inc.*
RIGHT: Old friends from past fishing adventures gather to mend nets in Gloucester, Massachusetts. *Nance S. Trueworthy, NOAA Fisheries*

Small-scale fishermen and yachtsmen, such as these Texans in Port Aransas, have learned to co-exist peacefully. *William B. Folsom, NOAA Fisheries*

longstanding lifestyles and social traditions. This trade-off, though, is the clear pattern of industrialization, with similar outcomes in such other production industries as farming, ranching, and logging.

In the United States and other developed nations, small-scale fishermen may have considerable income and a good standard of living. In common with such fishers worldwide, they also generally have little economic or political power. This isn't always the case, though: when faced with potentially disastrous legislation, small-scale fishermen have sometimes formed coalitions to successfully influence local and national legislators. Many of the nation's elected officials, especially those from coastal states, are quite mindful of the potentially great voting blocs in coastal communities that depend heavily on commercial and recreational fishing.

As with most businesses, a large-scale enterprise always has greater social and economic influence than a single small-boat operation (although some large-scale fishermen and recreational business lobbies often seem to cancel each other's advantage). Sizable fishing and processing operations tend to be run by individuals who are well educated, financially secure, technologically sophisticated, and—most important—very politically savvy. This disparity of power has long been a source of great unhappiness to many small-scale fishermen. But the pain isn't limited to small-boat owners. The crews of some large-scale operations tend to see the vessel owners and industry middlemen as entirely too greedy, unwilling to fairly share profits with the actual workers. Some vessel owners, in turn, cry their own litany of discontent: unfair competition (especially foreign), greedy buyers and processors, exorbitant mortgage or insurance rates, stringent government regulations, and a host of other forces that singly and in combination reduce their profits. Despite such perils, many crewmen in America probably have the same dream: owning their own boat.

FISHING AS SCIENCE AND ART

Like farmers and others whose success—and sometimes, survival—depends as much on nature and chance as on skill, fishermen are seemingly always on watch, with one eye on the horizon. In fact, the very word "watch" describes fishermen's traditional unit of daily work, and reflects this need for alertness to the weather and other conditions (including vessel traffic). But good eyes and ears don't guarantee economic survival. Dwindling resources and growing fleets have meant for some fisheries only a few days of fishing each season. Thus, many boats—commercial and sport, large and small—are crammed with a dazzling array of electronics: radar, sonar, Loran navigational systems, satellite communications and imaging technology, sophisticated computers, wide-frequency radios, and mobile and cellular telephones. And pilothouse shelves are choked with permits, regulations, navigational charts, fishing logs, weather maps, and guidebooks to help maximize fishing in narrow "fishing windows."

Technology has also created "black box" technology to record a vessel's whereabouts for law enforcement purposes. On the horizon are identification card scanners that let a permit holder notify managers when the vessel is leaving or returning to port. While they're still at sea, fishermen receive reports of current fishing conditions and regulatory changes and, in turn, report their catches "real time" via fax, electronic mail, and telephone.

Although regulations may have spurred some technologies, most of management's current role has resulted from advances in fishing efficiency. Greater efficiency (here, the catching of more fish) has come with increased engine and hydraulic power that can get boats to the grounds and back to port faster, pull bigger nets or set more lines or traps, and store more catch aboard. Not surprisingly, over time, this fleet power has led to declines of many of the most valuable stocks. And as catches have diminished, the heavy investment in boats and gear—often a financial maelstrom of liens and mortgages—has reduced profits.

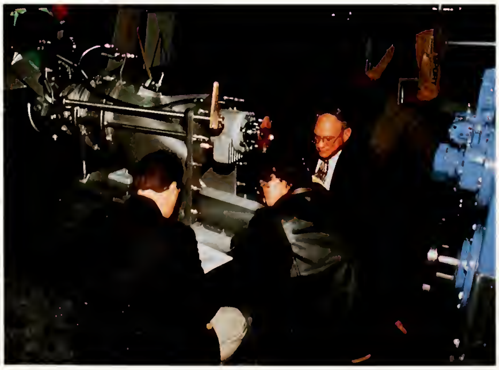
This state-of-the-art technology can't guarantee fishing success. Fishing is still primarily an art, or craft, and crews value those among them whose experience, skill, and instincts lead the vessel on safe trips to productive fishing grounds. "Good" skippers must first be good navigators who can find their way to the concentrations of fish. They must intimately know the sea's depth, currents, bottom types, reefs, and sandbars if they're to avoid gear loss, and they must understand the patterns and habits of their targets. And something more: if they're to find the best markets in a timely way, they must have an accurate sense of who else is fishing for these same targets, where those rivals are likely to sell their catch, and for how much.

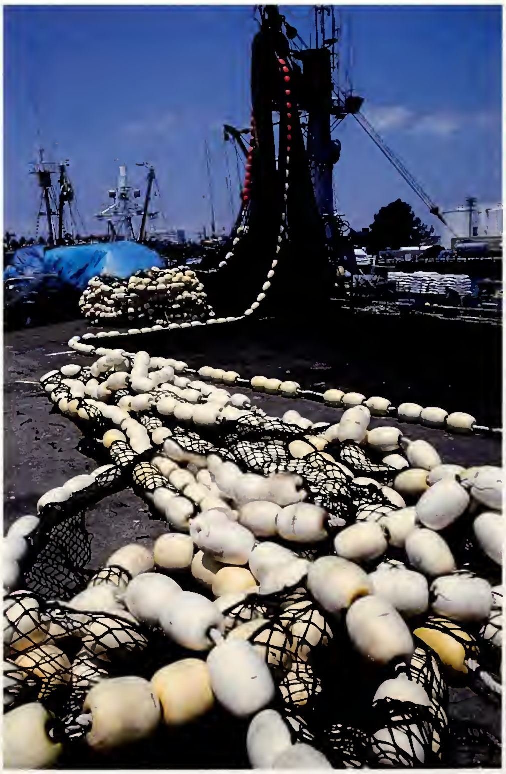
Beyond learned skills and extraordinary observation habits, though, even the deckhands on fishing boats seem to develop a sixth sense when it comes to finding their targets. Experienced fishermen often claim they can "smell" the fish as they near the fishing grounds. In fact, they may indeed have developed a sensitivity to the presence of certain types of fish. For example, some shark fishermen may be sensitive to the minute quantities of ammonia compounds that characterize shark flesh. Other fishermen are extremely sensitive to the minute sea-state changes that portend weather shifts, or they can spot from a great distance the surface riffles of foraging fish.

Fishermen are remarkably cooperative, forming loose networks that often share helpful information at sea (sometimes in "coded" radio messages that can be readily understood only by other crews in the code group). Skippers readily use their radios to update trusted colleagues on where the fish are concentrated, where bycatch is heavy, current Coast Guard enforcement operations, and the going market prices of various target species. On shore, boat owners, skippers, and crews exchange information and passionate views on regulatory regimes, the latest fishing gear and technologies, and sources of financing, insurance, and dockage. Interestingly, but perhaps not surprisingly, studies have shown that crews fishing depleted or otherwise scarce resources tend to hoard information that is freely shared among those harvesting an abundant or underutilized stock.

Professionals in the recreational fishing industry generally cooperate, too. Even though they're often in tough competition for the customer dollar, their common goal is to provide customers with a

TOP LEFT: The bridge of a modern fishing boat is a wonder of technology and human ingenuity. © *Allen M. Shimada.* **BOTTOM LEFT:** Fishermen's time away from sea is often spent checking out new technologies and equipment at trade and industry shows. *Courtesy of Diversified Business Communications.* **RIGHT:** Immense power winches, like this one loading nets onto a Los Angeles tuna boat, helped build the purse seine industry. *William B. Folsom, NOAA Fisheries*





LONG HAUL
USA

FLORIDA'S FINEST FISHING
Captain Bubby Hall
HALF DAY · FULL DAY
642-4437
OFFSHORE CHARTER FISHING
Wild Thing
394-4966
DIVING LOCAL WRECKS & REEFS
BACKWATER &
Sport
B
A

LEFT: The "good" skipper: navigator, fish-finder, technician, businessman. © *Brad Matsen.* **TOP RIGHT:** A crewman offers up grilled salmon at a dockside barbecue in Kodiak, Alaska, to benefit his fishing organization. *Charlie Ess, NOAA Fisheries.* **BOTTOM RIGHT:** Charter boat and partyboat fleets are characterized by both intense competition and strong cooperation. *William B. Folsom, NOAA Fisheries*

pleasant fishing experience. The information shared by charter boat and partyboat skippers is similar to that of commercial operations—regulations, technology, and support services. In addition, they often refer potential customers to neighboring boats when their own boat is full or the client's needs are best met elsewhere. Just about everywhere along the nation's coastline, the salt air faintly crackles with sport boat radio transmissions about fishing conditions, winds and sea states, and areas where commercial boats are concentrated.

There is also a surprising amount of cooperative radio traffic between commercial and recreational vessels—storm alerts, warnings of areas where traps and lines have been set, and information on merchant ship traffic or the presence of large numbers of protected porpoises or sea turtles. Commercial and recreational vessels, however, seldom exchange information about concentrations of species both sectors are targeting, even where each sector has its own quota, in order to avoid gear entanglements on the same fishing grounds.

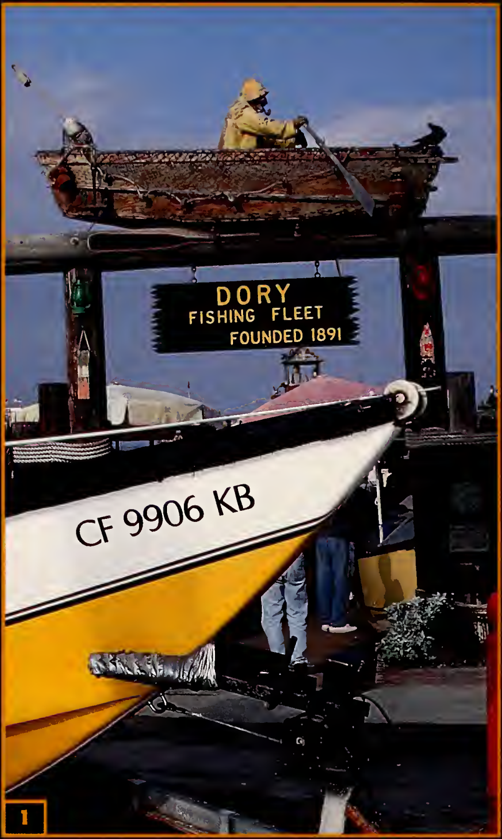
Fishermen depend on navigational aids, such as these buoys that will mark a Wanchese, North Carolina, channel. *William B. Folsom, NOAA Fisheries*

INDUSTRY-WIDE HEADACHES

Most fishermen grumble that their biggest headache is the myriad state and federal rules and procedures that govern almost every aspect of fishing, even while everyone recognizes the need for such regulations. Some of the resentment stems, of course, from fond memories of a mostly unregulated fishing era (which, in hindsight, led to much overfishing). Even the most dedicated fishery managers and enforcement officers are hard-pressed to keep up with changing regulations on gear.

DORY FISHING: A LIVING HISTORY

In spite of technological advances, some American fisheries seem to have maintained a unique character. So it is with the little dory fleet launched daily in the surf of Newport Beach, California, for more than 100 years. The few participating boats, a specially licensed part of the Pacific groundfish fishery, have earned both designation as a state historic site and a special federal allocation of rockfish and sablefish (black cod).


DORY
FISHING FLEET
FOUNDED 1891
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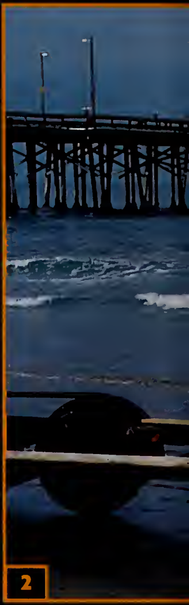

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WELCOME ABOARD

4

1 The dory fleet market sports embellishments to attract tourists as well as buyers. **2** Dories are trailered to the beach every day, a strategy that saves time and docking fees, and maintains the little fleet's traditional operation. **3** A two-man crew moves the morning's longline catch from dory to customers, all within a hundred yards. **4** Rockfish and sablefish are the dorymen's big sellers, but other species, like the mackerel shown here, help keep the market going when rockfish are scarce. **5** Eager buyers make their selections from the morning's bountiful catch of rockfish and sablefish. **6** Fish are filleted or sold whole within hours of being hauled up from the relatively deep water off Southern California.

Photos by William B. Folsom, NOAA Fisheries.

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29245
1991
COMMERCIAL SALMON VESSEL PERMIT
NO. 29245
NOAA FISHERIES
EXEMPTION

TOP LEFT: Fishing is a complex business, requiring fishermen to obtain—and display—myriad licenses, permits, and registrations. *William B. Folsom, NOAA Fisheries.* **RIGHT:** Fishermen in Prince William Sound, Alaska, work to contain the massive 1989 oil spill that jeopardized salmon stocks. © *Brad Matsen*. **LEFT:** Logging is only one of the many industries that helped degrade salmon habitat in the Pacific Northwest. *Courtesy of Gene Cope, NOAA Fisheries*

conservation devices, vessel logbooks, prohibited catches, minimum (and, in some cases, maximum) fish sizes, and closed areas and seasons. The skipper who fails to meticulously track these rules may well end up with heavy fines for violating them. And for almost every species taken, commercial fishermen must have an annual permit, with the end result being a substantial bookkeeping effort.

There are more than 100 basic fishery statutes that regulate what American fishermen may catch, possess, sell, or give away. And the most powerful of these, the Magnuson–Stevens Fishery Conservation and Management Act, is implemented across the country through an immense number of individual regulatory actions each year. Current government efforts seek to simplify regulations, but the intense level of resource utilization by so many different interests makes formal management an absolute necessity. Fishermen have no alternative but to expand their knowledge of fishing regulations, along with their understanding of the additional species' life cycles and distribution patterns.

Both commercial and recreational fishermen must also comply with other maritime laws that have nothing to do with catching fish. There are hundreds of safety and boating regulations, anti-pollution laws, and insurance requirements that, like fishing regulations, undergo such frequent revision that fisheries managers, enforcement officers, and even government lawyers sympathize with the industry's frequent confusion.

As mentioned earlier, commercial fishermen's livelihood and anglers' pleasure are also harmed by the activities of other industrial sectors—hydropower, manufacturing and refining, construction, agriculture and logging, and municipal waste disposal. Much of this activity is responsible both for direct fish kills and for sublethal effects that may reduce a region's fish stocks. Fishermen are seldom compensated for economic losses suffered as a result of pollution, even when the source is known. Recently, though, fishermen losing income as a result of closed waters are demanding corrective action. The impact of pollution is greater on small-scale fisheries, of course, because most of them operate in nearshore waters, where pollution is worse.

Perhaps the greatest displacement of commercial fishing has come with the phenomenal growth of recreational fishing. Although long popular as a leisure activity, saltwater recreational fishing didn't attain great political force until the late 1970s, when advocacy groups began insisting that anglers get a "fair share" of many highly valued species. In fact, the efforts of powerful recreational coalitions have secured game fish-only status for several species, and have wrested very respectable "recreational shares" for many others.

Even without these societal changes, fishermen's lives are stressful. Perhaps most painful is the nature of fishermen's income. Markets for fish products are notoriously

SEA MATE
FOR SALE BY OWNER

LEFT: Intense competition and diminishing profits have forced many long-time fishermen to abandon the trade. *Courtesy of Pacific Fishing magazine.* **TOP RIGHT:** A shark taken as bycatch in a west coast groundfish trawl is now unavailable to the directed shark fishery. © *Allen M. Shimada.* **BOTTOM RIGHT:** Both large- and small-scale vessels must keep the catch cold, which often adds substantially to operating costs. © *Sharon Pieniak*

unpredictable, with dramatic fluctuations of dockside prices between the time fishermen put to sea and when they return. Other economic conditions also diminish profits, as when production costs (fuel, insurance, gear and equipment, etc.) rise faster than the prices paid for catches. Adding to financial woes are declines in many fish populations, and fierce competition—from foreign products, rivals from other ports, and even friends and relatives working on other boats.

Competition among fishery sectors has, in fact, been one of the worst problems, with incursions by one fleet with reduced catches and diminishing profits onto the grounds—and into the profits—of neighboring fisheries. Both large- and small-scale fishermen often have permits to fish in many fisheries, frequently changing gear and practices to take advantage of whatever can be caught in a profitable quantity. But as needed management measures closed one fishery, a domino-like effect sometimes occurred as vessels were forced to take other species, until that fishery closed, too. "Switching" among fisheries can be a successful weapon against the uncertainty associated with fishing and the increasing overcapitalization, but it is indeed a double-edged sword.

Fishermen often feel despair over what they see as a basic unfairness between the way they're treated by the country, and the

LEFT: Ice-encrusted decks and gear, like this trap aboard a North Pacific crabber, make for a hazardous workplace. **RIGHT:** Ocean-going fishing vessels can expect to encounter heavy, sometimes perilous, seas on almost every trip. *Photos © Brad Matsen*

apparent favoritism shown to other food-producing industries. They especially like to cite the government-provided agricultural subsidies and federal crop insurance, which provides $2 billion a year to protect farmers against environmental disasters—floods, droughts, and pests. Only small subsidies exist to compensate fishermen for damage to their resource and, unlike some farm crop subsidies, fishermen are not paid for not fishing.

A PUNISHING LIFE

The actual work of commercial fishermen is demanding to the point of genuine hardship, although this varies widely by fishery and gear type. Fishermen who work on larger boats must spend long periods at sea, away from their families. Many other fishermen work singly or in two's or three's aboard small boats that return to port after a day's (or night's) fishing.

LEFT: Ice-covered decks and a continuing snowfall are no excuse for ignoring net-mending chores aboard this Portland, Maine, dragger. © *Nance S. Trueworthy.*
RIGHT: Fire—both at sea and in port—is an ever-present danger on fishing vessels. *Courtesy of* Pacific Fishing *magazine*

Regardless of how they fish, though, life aboard many fishing boats is Spartan and uncomfortable—and often dangerous. There is always a threat of storms, accidents, or mechanical failure. Saltwater and briny winds bring rot and decay to both boats and gear, posing a constant threat to the crew's safety. The eight-hour shift isn't common in the fishing industry, and most fishermen work very long hours on wet, rolling decks, surrounded by wire cables that can snap off an arm and massive nets that can sweep a worker overboard in a flash. Despite an increasing number of safety regulations, several overloaded or unbalanced boats are lost in heavy seas with their crew each year. With its high injury rate, fishing is considered one of the most dangerous jobs in America.

Between at-sea perils and the high level of financial uncertainty, commercial fishermen live an angst-filled existence. In fact, the prestigious *National Business Employment Weekly* rates fishing as one of the 25 most stressful occupations, along with U.S. president, firefighter, police officer, U.S. representative and senator, and airline pilot.

Fishermen's lives depend on close cooperation. They have to ignore the internal ocean of bruises, sore muscles, and wounds that invariably come from working on crowded, slippery, even icy decks. When not actively hauling gear or sorting the catch, fishermen must do the chores necessary to keep the boat and gear serviceable—washing down decks and gear, painting rails, stowing gear, splicing lines, and mending nets. Physical labor is a constant, and eight hours of sleep, a rarity. As a result, fishermen suffer from bad backs and arthritis caused by years of grasping frost-covered lines. And many veteran fishermen are hard of hearing as a result of the constant, close din of pounding diesel engines and screaming winches.

The fisherman's few nonworking hours at sea aren't particularly pleasant either, and there aren't a lot of stress relievers on board. The crew eats and sleeps together in tight, spare quarters. And except for very large boats, privacy is an unattainable luxury, as are hot showers and clean clothes. At-sea recreation is scarce, but, for that matter, there's not much spare time or space for it anyway. Almost every square inch must be reserved for fishing and safety gear, food and fuel, and, of course, the catch. Rolling seas make chess and even reading challenging, and dampness seems to penetrate every corner below decks. And though modern satellite relays have made communications easier for crews and their families, even allowing for play-by-plays of hot football games, bad weather conditions often terminate all transmissions. The public's sometimes romantic image of commercial fishermen is slightly wide of the mark.

AWAY FROM SEA

If "sea time" seems a constant struggle for fishermen, "family time" can also be frustrating. Many fishermen come from patriarchal cultures, and a man's short, sporadic return to a household necessarily run by his wife can result in domestic tension. Fishing families, like military families, are adapted to living apart. Often themselves raised in fishing families, wives have a profound understanding of the hardships, uncertainties, and absences of such a life. Even so, many fishermen complain that they feel like a fifth wheel

One MAN One BOAT

Although some commercial fishing operations, such as groundfish trawling in the North Pacific and New England, are mammoth ventures with large crews, the vast majority of fishing boats in the United States are quite small businesses, often with a crew of just one or two. If this is still the trend among fishermen, it is because they prefer it that way. They like owning their own boats.

Gene Stanford is such a person, generally setting his lines and traps for the Chesapeake Bay's blue crabs by himself, although he sometimes takes a friend or family member along. For fishermen like Gene, who works out of St. Michael's, Maryland, the solitude of a one-man operation is its own reward, with no one to order him about or tell him his business.

At first glance, this seems like a very simple lifestyle: set the gear in the morning, pick it up at night, sell the catch to a dealer. A closer look, however, generally reveals a type of individual who's independent, resilient, and gifted with many skills—sensing where the fish are and how long to leave the gear down, manufacturing or repairing dozens of items aboard the boat, and negotiating the best price for the catch. There's no color bar here, or artificial limit on age, religion, or gender: profits go to those who can catch fish. In that sense, then, the little "mom-and-pop" fisheries of America are the stuff of the nation's greatness.

Gene Stanford, St. Michael's, Maryland (William B. Folsom, NOAA Fisheries)

LEFT: The relaxed atmosphere of small-town coffee shops and taverns is a pleasant contrast to the exhausting onboard life. **ABOVE:** Modern fishing families are often very close-knit, and increasingly spend the hours between trips together. *Photos © Nance S. Trueworthy*

at home and retreat to a tavern or coffee shop where patrons are mostly the fishermen they were eager to leave just awhile earlier.

The role of women in fishing communities—never secondary—has increased dramatically in recent decades. Fishermen's wives have always been important to the business end of the operation: marketing and bookkeeping. In fact, they often have greater prestige in the community than women in nonfishing families. In many areas, such as New England, Alaska, the Southeast, and Hawaii, women have become a dominant political force, creating strong fisheries lobbies, operating boats and brokerages, and very effectively representing fishermen's interests at meetings of Fishery Management Councils.

The American fishing family, though, is undergoing great change. Stringent management is everywhere reducing fishing days, and as one after another fishing season is closed or shortened because of intense harvesting pressure or bycatch concerns, fishermen spend less time at sea, though not by choice. As a result, most small-scale American fishermen, and many working in larger operations as well, are either part-time or seasonal operators. However, this increased shore time has had some benefits, such as allowing fathers to participate in family-

LEFT: The number of women entrepreneurs, like this seller of skates for lobster bait in Pt. Judith, Rhode Island, is increasing in fishing communities. *William B. Folsom, NOAA Fisheries.* **RIGHT:** Fishermen's boats always seem to need painting, but it's a hard way to make a living. *Edward J. Pastula, NOAA Fisheries*

centered and community activities, for example, scouting and school sporting events.

Traditionally, fishermen's limited time on shore was devoted to boat and gear maintenance, and although fishermen can still be seen painting rails or making nets, there often isn't enough work to pay all the bills. So more and more fishermen are engaged in nonfishing work, often as self-employed craftsmen or as seasonal or part-time workers in other industries. Some crewmen, of course, are so highly skilled that they're in demand by vessels in several fisheries. But most fishermen have outside sources of income—boatyard work, engine repair, netmaking, machining, even furniture manufacture. Quite a number of commercial fishermen also work on or own charter boats, head boats, or partyboats. Whatever their supplementary work, fishermen tend to see themselves principally as harvesters of the sea's resources.

WHY THEY FISH

Looking only at the brutal, disruptive conditions faced by so many fishermen, this seems a puzzling occupational choice. The reasons are complex, but many national and international studies have helped explain this seeming paradox. First, of course, fishing can be lucrative. In addition, many fishermen come from fishing families. They go to sea in their early teens and eventually settle into fishing to keep the family boat or business operating, or perhaps because they are unskilled for other kinds of work. At some point, the sons—and sometimes daughters—of fishermen strike out for themselves. Hence, the proliferation of fishing operations that has unfortunately added to the erosion of individual incomes.

Many people enter and remain in the fishing world for reasons that reflect basic cultural or personality types. Some like the family-centered nature of fishing, and appreciate working with others of a particular ethnic background, many of them family members. They may, at the same time, enjoy the relative independence of fishing—"being their own boss"—or smooth teamwork and egalitarian relationships (very few captains really choose to exercise their authority openly). Most fishermen are physically hardy and tend to enjoy physical labor, and except for the worst winter days, they like being outdoors. A great many of them express their pleasure in providing food for the nation and take pride in their designation as specialists by resource (crabbers, lobstermen, oystermen, shrimpers, and clammers) or gear (netters, harpooners, trollers, tongers, and draggers/trawlers).

Fishing, of course, is still primarily a male occupation. Many men thrive on the virile nature of the work, and on the danger and uncertainty that characterize fisheries. Unhappily, some exaggerate this machismo to the point of aggression, with an unfortunate and predictable community backlash against fishermen as a group. As a result, there is often considerable social distance and ethnic tension between fishermen and the larger society—hardly a recipe for positive community relationships. This very social isolation also serves as a sort of bonding and empowerment device that helps such fishermen withstand perceived social—and fishery management—injustices.

In some instances, the pay system, if not the actual remuneration, appeals to fishermen. Most crewmen aren't paid a flat fee or wage, but instead work within a shares system that puts great emphasis on cooperation. Each member of the crew—including the captain,

Many fishermen, like these Gloucester, Massachusetts, swordfish longliners, enjoy the independence of a two-man crew. *Nance S. Trueworthy, NOAA Fisheries*

TOP LEFT: Much of the work on board a fishing vessel still requires brawn and stamina. © *Brad Matsen.* **ABOVE:** A good day's catch—in this case, Copper River king salmon from Alaska—is rewarding only if the buying price is good. © *Brad Matsen.* **NEAR LEFT:** On board or on shore, like this net shop in Cut Off, Louisiana, relaxation is wherever—and whenever—one can get it. *Lauri Lawson, NOAA Fisheries.* **BOTTOM LEFT:** In spite of grueling conditions, these North Pacific crabbers and other fishermen look forward to their trips. *Courtesy of Pacific Fishing magazine*

mate, cook, and sometimes, airplane spotter pilot—receives a portion of the catch, effectively increasing everyone's incentive to perform well. (It is illustrative of their value to the rest of the crew that cooks usually get at least the same share as deckhands working the gear.) Though share allocation plans vary, generally the captain or owner receives a larger number of shares to cover the costs of the boat (fuel, repairs, food, insurance, dockage, etc.) and equipment. Sometimes, too, a larger portion goes to the highly skilled specialists termed "master fishermen."

Since the crew's earnings depend on the boat's success, the best workers will tend to seek out the most successful skippers, and extensive shifting around can lead to real instability within a fishery. As fishing enterprises become more vertically integrated, with a single corporation owning both fishing and processing components, or as industries come under resource "ownership" programs—for example, individual transferable quotas, or ITQs—pay structures may shift away from shares to set fees.

A substantial number of fishermen forced to work part time at other occupations still list fishing as their major occupation. Indeed, the sea's beauty and drama make for a powerful lure that continues to attract young people to this world. Whatever the enticement, fishermen almost always perceive their work not as simply a job, but a way of life.

Nevertheless, fishermen's satisfaction with their work is highly elastic, and greater in some fisheries than in others. Generally, of course, higher earnings make for greater satisfaction. There are other considerations, all highly variable from individual to individual, and even within one person at different periods of life—length

ABOVE: A Samoan family continues a long tradition of fishing nearshore waters from outriggers. © *Bonnie Ponwith.* **TOP RIGHT:** In some areas like Kodiak, Alaska, women have found a place aboard fishing boats as both skilled workers and owners. *Charlie Ess, NOAA Fisheries.* **CENTER:** A Tarpon Springs, Florida, sponge fisherman proudly announces his heritage with the traditional Greek fisherman's cap. *William B. Folsom, NOAA Fisheries.* **BOTTOM RIGHT:** An altar in Gloucester, Massachusetts, is evidence of the role of faith among people practicing a dangerous profession. © *Nance S. Trueworthy*

of fishing trips (time away from home), educational level and life views, whether supplementary sources of income are available, whether the fisherman owns the boat, compatibility with co-workers, satisfaction with the captain or boat owner, the nature of regulatory regimes, and family and personal circumstances.

THE COMMUNITY OF FISHERMEN

Fishing communities throughout the world have readily identifiable cultures. The nonfishing public tends to see only the trappings—boats, nets, buoys, and, of course, the catch. The fisherman's workplace is often in plain sight because it is moored at docks fully accessible to the public. Even visitors to yachting marinas are exposed to commercial operations, for in spite of competition and conflict between commercial and recreational fishermen, boats from both sectors—and the strictly yachting community—are often moored together quite peacefully at multipurpose marinas. Such facilities offer proximity to services they all need, such as fuel, pumping (waste disposal) stations, engine repair shops, and hardware stores.

Like farm towns, fishing communities tend to have traditional, conservative values, and third- or even fourth-generation fishermen often identify strongly with their immigrant forebears. Many American ports are multicultural, but others have a decidedly ethnic character with distinct traditions and values. Boat names, dockside restaurants, seafood markets, community banks, and fishermen's faces may announce an Italian heritage (and fishing style), or Cajun, Portuguese, Vietnamese, Mexican, Slavic, Native American, and many other cultures. There are African-American fishing communities in Chesapeake Bay, Eskimo villages in Alaska, and Polynesian fishers in

LA MADRE
S S DEL LUME
PROTECT
OUR
FISHERMEN

Many fishing communities, such as Portsmouth, New Hampshire, cherish their annual Blessing of the Fleet. © *Nance S. Trueworthy*

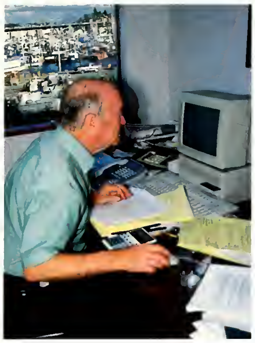
the Western Pacific. In common, though, fishing ports tend to be composed of tightly knit families whose closest friends are other fishing families and who respect the same cultural traditions and taboos.

Reflecting this ethnic potpourri and frequently strong religious belief, many ports have special blessing ceremonies to ensure the safety and success of the fishing fleet. Chapels and temples are common near fishing docks, and many captains adorn their boats with religious statues or altars. As one might expect, where luck often spells the difference between success or failure—or even life or death—many fishermen are superstitious. Painted cow horns, antlers, and other amulets can be seen hanging from the wheelhouse of some boats, and others sport large eyes painted on the prow to ward off the "evil eye." The tailfins of freshly caught sharks are nailed to the wheelhouse as good-luck charms, and tuna boat crews avoid crossing utensils in the galley to prevent bad luck. And in common with mariners everywhere, vessel owners think very carefully before changing a vessel's name—and its luck.

Religious beliefs and traditions serve to unify crews and fishing communities. Fishermen's festivals, fairs, and jamborees are common, with fishermen often foregoing a fishing trip in the middle of the season to celebrate with their families. Many ports sponsor annual boat parades, where usually more somber fishermen lavishly decorate their vessels and dress themselves and their entire families in colorful, often amusing, attire. The irony of these events' tourist appeal, even as some citizens openly disapprove of fishing activities, isn't lost on fishermen. To their credit, everyone is welcome to these festivals.

Almost across the board, America's commercial fishermen agonize over the public's increased antipathy—or at best, indifference—to the fishing profession. This "we" (fishermen) versus "they" (the general populace) polarization is so pronounced in some coastal towns that failure to buy into the prevailing group sentiment is suspect. Dissenters are sometimes shunned at community events, but when opponents share tight ship's quarters and

BELOW: A great many fishing operations are family affairs, like this one in Newport Beach, California. *William B. Folsom, NOAA Fisheries.* **TOP RIGHT:** Fishermen's festivals are universally joyous and include all family members, like this wives' tug-of-war. © *Nance S. Trueworthy.* **BOTTOM RIGHT:** An exuberant boat parade gives these Maine fishermen a chance to celebrate their attachment to the sea. © *Nance S. Trueworthy*



Private consultants, like Seattle's Dr. Lee Alverson, are important to both fishing groups and government agencies. *William B. Folsom, NOAA Fisheries*

cooperation is critical, any significant discord creates a very dangerous situation. Back on shore, families sometimes split into feuding factions, and entire communities get drawn into medieval-like cabals that boycott opposition businesses. Such feuds aren't very conducive to the unity and shared economic strategies needed in a highly competitive world.

Another sign of stress is the family's changed division of labor. Wives and daughters today aren't so available as in prior years to handle the business end of the family's fishing operation. In the past, with men at sea for long periods, women often handled the bookkeeping, bargained with fish buyers, and made the arrangements for new gear or vessel repairs. As a result of reduced fishing income, however, many women must now work outside the home, and have joined the vast army of those juggling jobs and family responsibilities. The bookkeeping and other office tasks get shortchanged at the very time they should be emphasized, with a sometimes disastrous outcome for the family.

Fishing communities must also contend with a changed role in the fisheries management process. Modern federal and state management systems were designed to let the industry participate directly. But for the system to work, fishermen must thoroughly understand the proposed measures and, even more important, take an active role in formulating them. At the federal level, this is done through frequent meetings of the Regional Fishery Management Councils. At the state level, proposed regulations are developed in meetings of state agencies or commissions, or the Interstate Marine Fisheries Commissions. Finding the time to attend all these meetings and study the vast number of pertinent reports is often an insurmountable difficulty for fishermen, requiring them to sacrifice precious fishing days—their very livelihood—or take time off from part-time, land-based jobs. And in some fisheries that require week-long—or even month-long—fishing trips, the meetings and hearings are out of the question.

Fisheries managers sympathize with this problem, and many can be heard uttering quiet prayers that the weather on meeting days will be so wretched that there wouldn't have been any fishing anyway. But since the management process requires advance notice of fixed meetings, more often than not, meeting days and good fishing weather coincide—to the fisherman's detriment.

This problem, of course, isn't restricted to commercial fishermen. Many recreational fishermen also struggle with whether to participate in council and commission meetings or attend to their own occupational needs. A good fishing day for commercial fishermen is usually also pretty good for recreational charter boat and partyboat businesses, and for individual anglers. Scheduling only night meetings hasn't proven feasible, since the agenda at any one meeting may require 20 or more hours of hearings and deliberation. In addition, fishermen are often tired after a day's work, and they sometimes have to travel long distances to attend the meetings.

As a result, stakeholders have developed some creative ways to provide input. Both recreational and commercial organizations have proliferated, employing salaried staff (including fishermen's wives) to represent members' interests at meetings, in legislative hearings, with government officials, and to the media. Some groups of fishermen have even set aside a portion of their profits to support one of their own number while he or she forgoes fishing income to represent group interests. Wives and other fishing family members now often attend management meetings as proxies for at-sea workers, and even have some strong organizations of their own to protect their sector's interests.

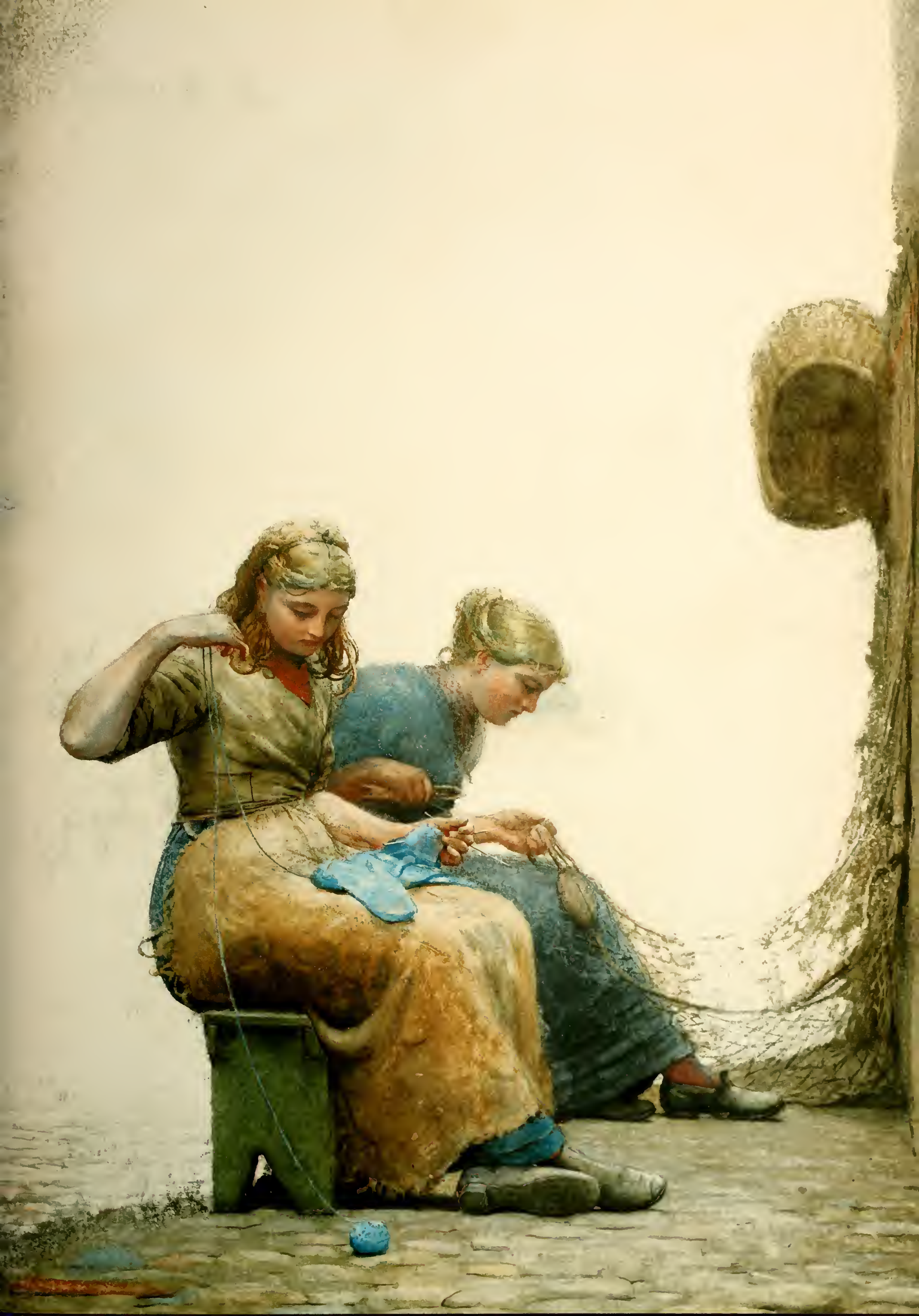
Communications serving the industry have had to change, too. Trade journals and other special-interest publications are no longer devoted mostly to articles on gear, vessels, market prices, and good fishing spots. They now devote whole feature sections to the political fisheries scene and controversial management proposals. Fax networks and Internet web sites not only distribute management and market information, but also sell and trade products, hawk literature, and, unfortunately, sometimes convey inaccurate information in fisheries-related "chat rooms." The life of fishermen has, indeed, undergone great change in recent decades.

LEFT: Fisheries trade magazines, such as *Pacific Fishing*, rely heavily on staff who know their way around docks, not desks. *Photos by William B. Folsom, NOAA Fisheries.* **BELOW:** Trade journals, like *National Fisherman*, are a growing influence on the operations and decisions of American fishermen.

Winslow Homer
Detail from *Mending the Nets*
Bequest of Julia B. Engel
Photograph 1998 © Board of Trustees, National Gallery of Art, Washington

4

TOOLS OF THE TRADE



The very act of catching fish implies the use of some tool or gear—at its simplest, one's hands. There are literally thousands of fishing methods in use throughout the world, and hundreds have been tried in the United States. Some global techniques and gears are used by "artisanal" fishermen, who fabricate much of their own gear or their watercraft (although the boats are now often powered by outboard motor). Few commercial fishermen use artisanal methods today.

Fishing gear is often spoken of as either "mobile" ("active") devices that are towed by a moving vessel, or "fixed" ("passive") devices that are stationary. These aren't very useful definitions, though, since there are so many exceptions. Not all mobile gear is towed, and some fixed lines and nets are moved during fishing operations. Gear moved through the water by means of a power boat generally takes larger catches than a stationary fish trap or impoundment takes. Mobile gear is usually far more costly to make and use and often requires larger boats and more crew members, while the simple and inexpensive impoundment and hook-and-line may provide their users with ample catch for their purposes. In addition, certain traps are so good at catching fish that they've been banned in some areas in order to keep fish populations stable. Finally, different target species require different gear—towing bottom nets over prickly coral reefs is a sure way to catch few snapper or grouper while tearing up

ABOVE: Most U.S. commercial fishing involves some kind of vessel, such as this little boat overwintering on a Maine beach. © *Nance S. Trueworthy*
LEFT: The largest commercial catches are taken by the gigantic North Pacific trawls. © *Brad Matsen*

FACING PAGE: Butterfish. *William B. Folsom Photography, Inc.*

or even losing the nets, and fishhooks aren't very useful anywhere for catching shrimp and clam.

The relative efficiency of gear, then, is not a particularly good way to think about fishing methods. And although some types of gear are used primarily by commercial fishermen, and other types by recreational fishermen, this isn't a very good way of classifying gear, either. Some types of smaller "commercial" nets are allowed in recreational fishing, some commercial fishermen also sell fish taken with the angler's rod and reel, and scuba is used for both commercial and recreational takes. But understanding America's fisheries requires a basic grasp of methods and gears. What follows is an explanation of the most common fishing methods used in America today, modified from the classification system described by Andreas von Brandt in *Fish Catching Methods of the World* (Fishing News Books, Ltd., Farnham, Surrey, England, 1984).

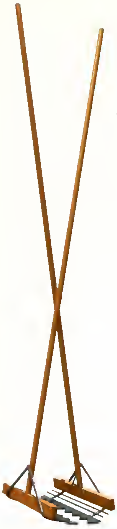
GATHERING

The simplest, and oldest, method of catching fish or shellfish is merely gathering them up from beaches, streams, rocky tidepools, and mudflats. Centuries ago, Northwest salmon were so abundant that Native Americans could simply pluck them from the water as the fish migrated upriver to spawn. Even today, inhabitants of some east coast communities look forward to river herring runs for the ease with which these fish can be scooped up by hand. Clam, oyster, mussel, and seaweed are often hand-gathered by both commercial fishermen and casual beachgoers, but even finfish can be captured when the waves recede, as with the smelt-like California grunion—in fact, that is the only legal way this species can be taken.

For the most part, though, those who either make their living from fishing or engage in recreational fishing use some type of gear. Some of the simplest tools are the hand rakes wielded for shoreline clam, oyster, and seaweed. Long-handled rakes, shovels, tongs, and hoes, and short-handled "irons," knives, and tines are used to harvest submerged invertebrates—sea urchin, abalone, mussel, seaweed, sponge, and conch. Most such gathering involves some type of diving gear (scuba, snorkel, hookah, or hard hat), a vessel to transport both diver and catch, and plenty of hot coffee to restore sensation after an hour-long submersion in frigid water. Diving is also common, though, in warm, tropical seas, especially to harvest molluscs (clam, pearl oyster, octopus), sea cucumber, and ornamental tropical fish.

Although more sophisticated gear is often criticized as damaging to marine habitats, simple gathering isn't entirely gentle on the environment, either. Some mudflats and beaches are continuously in a ploughed state from the boots and shovels of professional clam diggers (and weekend "sport" clammers). The use of rakes and hoes may also damage the tiny plants and animals that contribute to the health and stability of mollusc beds. Recent innovations—for example, the high-pressure water nozzles that flush out the larger clams buried deep in the mud, and hand-operated dredges (basically

Low tide affords fishermen a chance to gather herring roe attached to seaweed along a rocky Alaska shore. © *Allen M. Shimada*



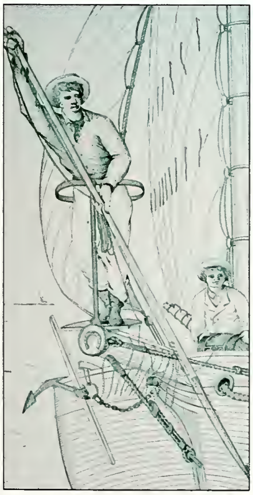
LEFT: Long-handled tongs are still used sometimes for taking oysters on shallow beds. *Jim Bean, Communications Collective/NOAA Fisheries.* **RIGHT:** Western Pacific coral reefs harbor colorful fish and invertebrate species gathered by divers for the aquarium trade. *© Tim G. Simos*

vacuums) that suck molluscs off the bottom onto a submerged screen mesh for separating and cleaning—haven't been well evaluated with regard to habitat damage.

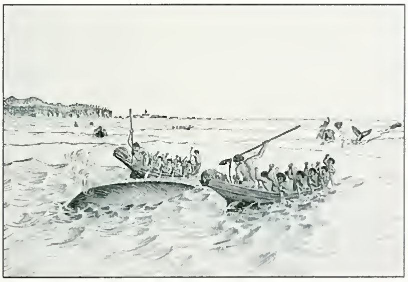
SPEARING

Spearing fish is perhaps the oldest method of fishing with a tool, and was probably used by every Native American culture living near streams or the coast. The technique is still surprisingly common in the United States, especially the spearfishing practiced by sport divers around reefs, shipwrecks, and kelp beds. Commercial fishermen also use spears, primarily for such large and valuable species as swordfish, tuna, and shark, but also for eel. And in North Carolina, flounders are taken in the shallow sounds by trident-wielding citizens indulging in the tradition known as flounder-gigging. This is essentially the same trident, symbol of the Roman god Neptune, that was used in the Mediterranean to catch tuna.

Stabbing at quiescent flounders is one thing; spearing—and holding onto—a fast-swimming giant swordfish is quite another. In the Atlantic and Pacific, this is usually done with a single, barbed harpoon. (Harpoons generally have one point and a short shaft; spears are longer, with two or three prongs.) Many Native American tribes, especially in the North Pacific, were masters of the harpoon, and the small amount of whaling permitted for today's Inuits in arctic Alaska is generally by this method. Modern harpoons are fired from a gun for a quick kill, to prevent the escape of mortally wounded whales. It has been suggested that the first fishing line was actually Eskimo walrus-hide line used with a harpoon. Other indigenous Americans sometimes still use hand-thrown spears, and fish bows with retrievable arrows, to capture shallow-water fish.



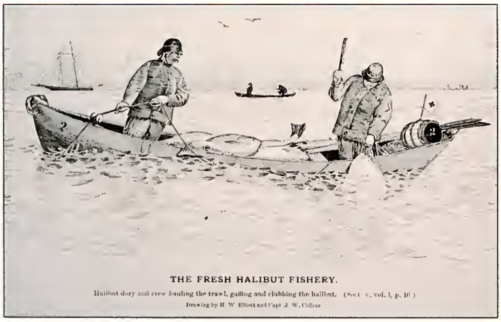
LEFT: A New England harpooner prepares to strike a swordfish in this 19th-century engraving. *Artist unknown. The Fisheries and Fishery Industries of the United States, NOAA Fisheries.* **CENTER:** For centuries Makah Indians used harpoons to take whales in Washington's Juan de Fuca Straits. *From a drawing by H.W. Elliott. The Fisheries and Fishery Industries of the United States, NOAA Fisheries.* **RIGHT:** Boys on a pier in Seaford, Virginia, handline for blue crabs. *Edward J. Pastula, NOAA Fisheries*

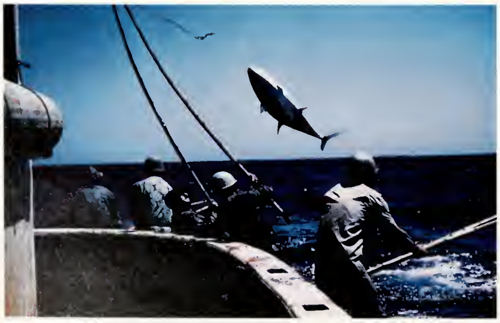


Some other types of simple but effective wounding methods were once common in America but are no longer used. Derivatives of toxic plants and other substances for "poisoning" fish in shallow ocean waters are used today only for scientific purposes (principally for fish censuses in a small pond or lake area, or to rid ponds of nuisance species). At one time, however, fish toxins were used by many indigenous people. Natives of the Alaskan Aleutian and Kodiak Islands actually impaled nearshore whales with "wounding spears," devices infected with lethal bacteria. After one or two days, a floating, sickened whale could be easily captured and dragged ashore.

LINES

If there is one piece of gear universally recognized as associated with fishing, it is the hook-and-line. Rare is the fisherman who has never snagged a finger, foot, or shirt pocket on a little steel fishhook.


THE FRESH HALIBUT FISHERY.
Halibut dory and crew hauling the trawl, gaffing and clubbing the halibut. (Sect. v, vol. I, p. 16)
Drawing by H. W. Elliott and Capt. J. W. Collins



But not all lines have a hook. One of the simplest methods of fishing—"bobbing"—involves only a humble piece of line and a bit of bait. Blue crab is caught all along the east coast by bobbing, frequently with chicken necks as bait. Bobbing for crab is also done in Hawaii, and Native Americans in California once bobbed for crab with a bundle of vegetable fibers. Lines with hooks, of course, have a distinct advantage: they prevent the fish from escaping once it has struck the bait.

Modern fishhooks come in a remarkable variety of sizes, shapes, and materials. There are barbed and barbless hooks, single and multiple hooks, spoons, lures, jigs, flies, and a whole host of other ingenious contraptions. But not all devices that snag a fish are "hook-shaped." Early Native Americans and other global cultures very effectively used "gorges"—little double-pointed sticks inserted into the bait to stick crosswise in the fish's throat following the strike.

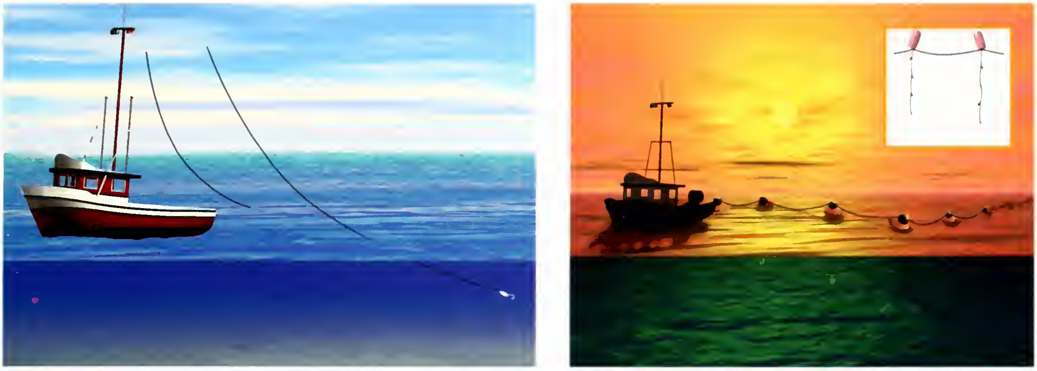
The simplest type of hook-and-line fishing is the handline—fundamentally a simple line with some sort of sinker and at least one hook, although there is often a dazzling array of special lures and floats. Holding the line in hand, a fisherman feels a bite, and then tries to "set" the hook in the fish's mouth to prevent it from escaping. Northwest Native Americans were reported to be exceptionally adept at catching halibut with a weighted handline designed to float just off the bottom.

Global histories repeatedly record the use of handlines with a simple pole, and sometimes, a reel or spool for holding lengths of line. This was clearly the origin of today's very sophisticated rod-and-reel outfit. In the commercial fisheries for albacore and some other large tuna, crewmen still sometimes use a single hook attached to two, three, or even four fishing poles where schools include very large fish. The animal's upward momentum on striking the hook is sometimes so forceful that fishermen simply guide it out of the water and over their heads onto the deck or even into the hold.

A very common adaptation of the pole-and-line is trolling. One or more lines are towed behind a commercial or recreational boat and rigged with a variety of embellishments—spoons, spinners, and feathered jigs, in addition to bait fish or cut bait—to take billfish, tuna, salmon, king mackerel, dolphin fish, and other species that strike at moving targets. Lines can be weighted to different depths, depending on which part of the water column the target species usually occupies, and commercial trollers sometimes spread many lines by means of a beam. Because trolling doesn't require a large boat, it's a very common fishing method for both commercial and recreational fishermen.

The desire to expand the number of fishhooks and, therefore, the quantity of fish that could be caught, led from handlines and pole-fishing to longlines, or set lines. Whether a longline is only a

TOP: Colorful lures with specialized hooks are intended to mimic the color pattern and action of a target species' prey. *William B. Folsom, NOAA Fisheries.* **CENTER:** Halibut taken on handlines are hauled aboard small dories working off New England in the 19th century. *From a drawing by H.W. Elliott and Captain J.W. Collins. The Fisheries and Fishery Industries of the United States, NOAA Fisheries.* **BOTTOM:** Two pole men work a single hook-and-line to bring aboard a large yellowfin tuna. *Scientific Publications Unit, NOAA Fisheries*



LEFT: A vessel rigged for trolling. **RIGHT:** Longlining from a small boat. **INSET:** Longlines set vertically. *Illustrations by Jim Bean, Communications Collective/NOAA Fisheries*

few hundred feet long or stretches for many miles, the basic configuration is the same: one main line with hundreds or thousands of hooks attached at intervals by short lines called gangions. Longlines are usually made of monofilament nylon or polypropylene, and can be rigged to fish on the bottom, mid-water, or surface, depending on the target species. The lines are typically set ("paid out") from a slowly moving vessel, which may then be anchored at one end. The gear is marked by buoys and flags or, for night fishing, by radar reflectors or lights to warn off other vessels.

Large-scale longliners often deploy and retrieve their gear by means of a large drum and hydraulic winch, although other systems set and haul back the lines through a series of reels and spools. As the line comes back on board, hooked fish and bait scraps are removed, and the gangions and hooks are detached and left hanging over the edge of a basket, tub, or special rod. Large operations use automatic baiting machines that let hooks pick up the cut bait rapidly as the line is being "shot" off the drum. Some also have disentanglers that clean the hook of bait and coil up the main line as it is brought back on board.

LEFT: A crewman pays out the longline from tubs aboard a small vessel. **RIGHT:** Hooks are baited with cut fish before being attached to the longline. *Photos © Brad Matsen*

There are many variations on longlining to accommodate the range of behavior in different target species. Floats keep "drift lines" on the surface or in mid-water, either in the common, stretched-out pattern, or in vertically aligned lines with many hooks. Longline fishermen in the Gulf of Mexico sometimes configure their vertical lines as "Kali poles," which fish well for deepwater snapper and grouper. Some of the best-known American longline fisheries are for Alaska halibut and sablefish; tuna, swordfish, and shark in the Atlantic and Pacific; and snapper and grouper in the Gulf of Mexico.

Although less costly and cumbersome than some net fisheries, longlining isn't without problems. The lines can tangle badly during strong winds or when hooked sharks or other large predators thrash around violently. The gangions are frequently bitten through, motorboats sometimes sever the longline itself, and even moderately heavy seas can make setting and haulback difficult. Bait-stealing, especially by seabirds attracted to the lines, is another headache, not only because of diminished target catches, but also because some of the main culprits—albatrosses—are endangered or threatened in some parts of the world. The Pacific longline fisheries are especially active in trying to reduce seabird bycatch, encouraging the use of fishing methods developed by Australian and New Zealand longliners: sinking baited lines rapidly, using devices to prevent birds from taking the bait, and setting gear at night when the birds don't actively feed.

TRAPS

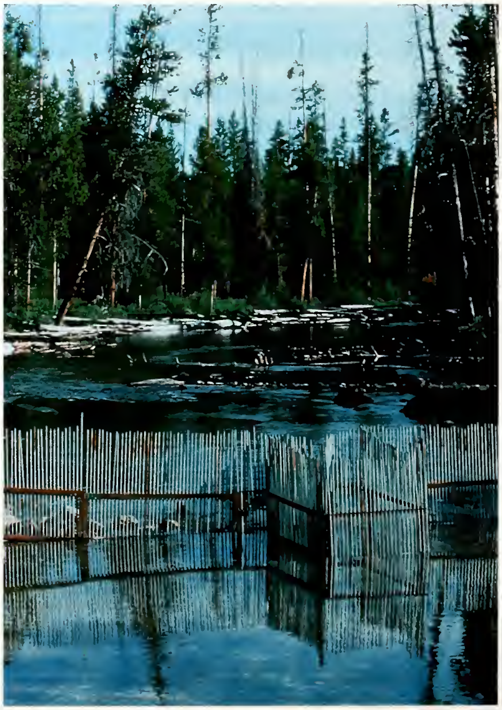
The principle behind trapping hardly needs explaining; most people are familiar with lobster or crab "pots." Traps to capture fish and crustaceans vary enormously in style and size. Many early Native American cultures built such ingenious shoreline devices as brushwood heaps that attracted herring and other animals in search of shelter or spawning areas. The trapper would then merely paddle out in a small canoe, lift the brush, and remove the catch. Similar brush traps are still used in Louisiana to catch "shedder" blue crab for the burgeoning softshell crab market.

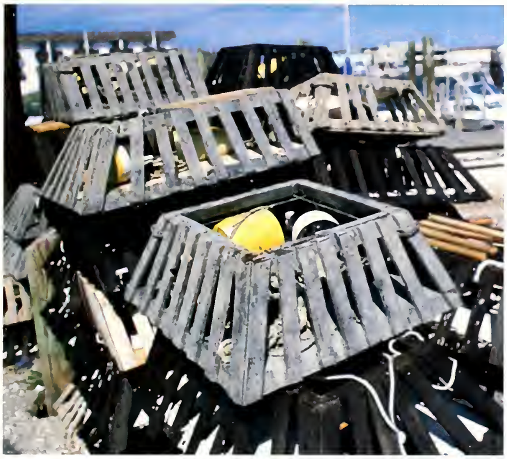
Somewhat more complex were the fiber screens made by Northern California tribes—devices that take advantage of flowing river currents to entrap migrating trout and salmon. Similar traps were used for eel fishing on the Atlantic Coast. Even more elaborate were the nearshore labyrinths of many eastern tribes. These impoundments were usually built at right angles to the shore and channeled the migrating fish alongshore into a holding area for later pickup. Early explorers and settlers in America were impressed by these efficient trap designs, which adorned streams, estuaries, and even the open coast. Combining these innovations with old-world pound nets, colonists installed an imaginative array of weirs, pound nets, and traps that caught both year-round fish residents and animals migrating through the area. Even today, the Northeast shoreline abounds with fish "fences" made from the same types of cane, willow, sweet grass, and other shrubs used by tribal inhabitants, and nearly identical in design to colonial impoundments.

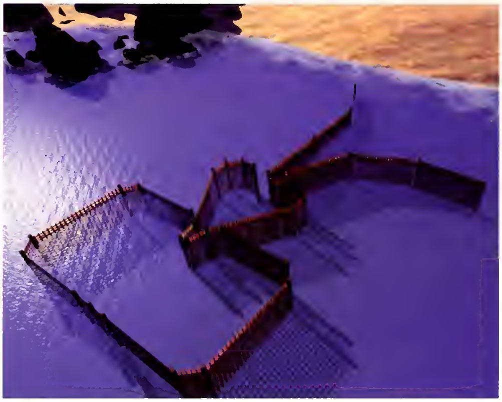
The barriers, called weirs, are usually made of wood, wicker, or other nontextile materials, while pound nets are mostly of netting. The size and configuration of such barriers vary considerably according to local conditions and the species targeted, but they all work by channeling fish into these mazes, from which escape is difficult. The fisherman then collects the usually quite lively fish at his leisure, using a spear, scoop net, or other hand gear. Large, floating pound nets, sometimes called "trap nets," are still used in Alaska and the Northwest to catch salmon—tourists often mistake these devices for aquaculture holding pens. Such nets can be very large, and are frequently damaged heavily by bad weather. Impoundments and weirs are generally temporary, but some have been permanent, as with the early Polynesian structures of piled-up stones.

Indigenous Americans didn't generally use the mechanical traps common in other world cultures, such as the bent tree boughs used to trip fishing lines. Some Native American tribes and Polynesian Hawaiians, however, used rope snares, sometimes with baited hooks, and inhabitants of the Marianas used a crossbow-shaped trap to snare crayfish as the crustaceans ventured from their holes. Similar "spring traps" for shrimp may have been imported to the colonies by African slaves. Few fishermen in the United States use snares today.

LEFT: Different styles of Pacific crab traps are stacked on shore in Seward, Alaska, along with marker buoys. © *William B. Folsom Photography, Inc.* **RIGHT:** A wooden-stake weir stretches part way across a Washington State stream to catch migrating sockeye salmon. *Rolland A. Schmitten, NOAA*





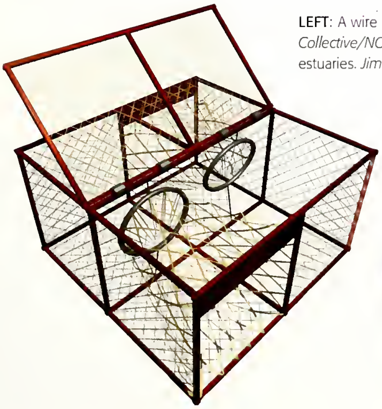


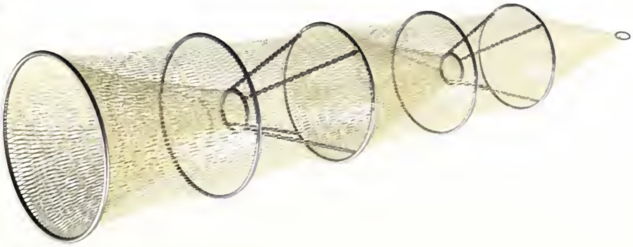
TOP LEFT: Specialized wooden traps are used to take whelk in shallow Delaware bays. *William B. Folsom, NOAA Fisheries.* **TOP RIGHT**: A crushed derelict trap finally washes up on the beach, where it no longer poses a threat to crabs and fish. *© William B. Folsom Photography, Inc.* **RIGHT:** An east coast pound net for taking nearshore species. *Jim Bean, Communications Collective/NOAA Fisheries*

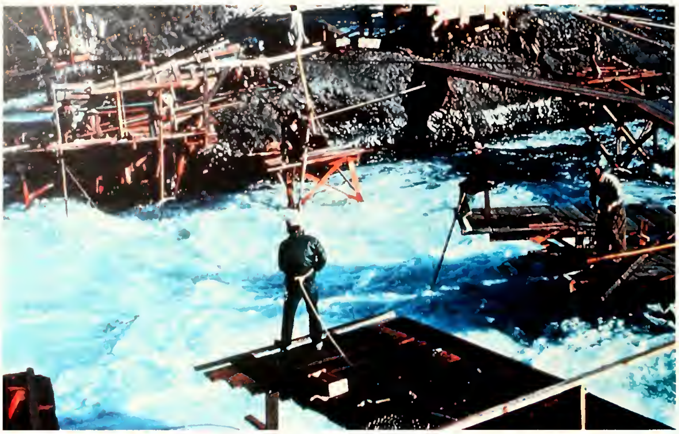
Although one can still see working weirs and impoundments, portable bottom traps are far more common today. The target species enters an opening, usually lured by bait or in search of shelter, and finds its way into the trap itself, from which it cannot then find its way back to the entrance to escape. Traps may be fished singly or in a string of many hundreds, but are always attached by lines to surface buoys that help fisherman find the gear. If only a few traps are set, the line connecting them is attached to a tender boat. In the United States, traps are used for anything that inhabits the bottom: crabs, lobsters, shrimp, and fish—and even the slow-moving but still mobile whelk.

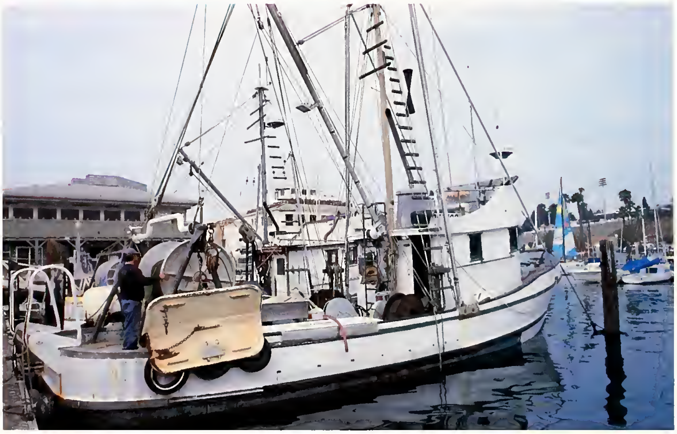
Until recently, most traps were wooden, combination wood and netting, or, in tropical areas, woven of bamboo or reeds. Unfortunately for fishermen, these natural materials tended to decay rapidly, although this had an ecosystem-friendly repercussion: if lost at sea, the traps soon rotted, rendering them harmless to the fauna. Traps today, however, are more durable, usually constructed of galvanized steel or plastic-coated welded wire. The down side is that "ghost traps" break loose and ensnare and kill animals, sometimes for years. Lost traps are thought to play a part in reducing the yield of crabs and fish. Thus, most of them

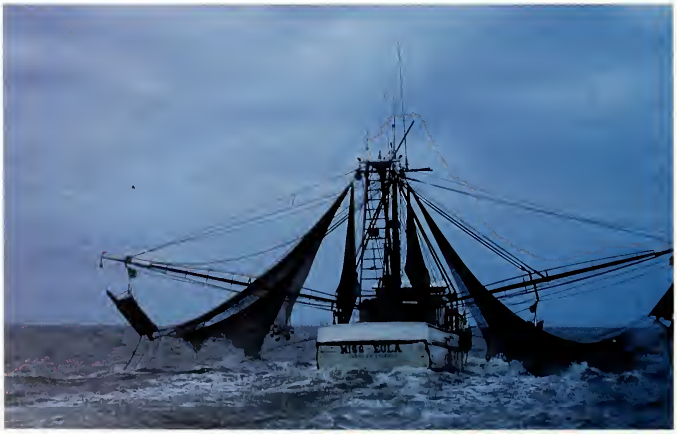
LEFT: A wire crab trap, which can be modified to target other crustaceans and finfish. *Jim Bean, Communications Collective/NOAA Fisheries.* **BELOW**: A mesh fyke net suitable for catching fish in calm coastal streams and estuaries. *Jim Bean, Communications Collective/NOAA Fisheries*











TOP: Native Americans in the 1950s work from wooden platforms on the Columbia River to take returning salmon. *Scientific Publications Unit, NOAA Fisheries.* **CENTER:** Steel "doors" hung on the stern of this moored vessel in Santa Barbara, California, advertise its use as a trawler. *Willliam B. Folsom, NOAA Fisheries.* **BOTTOM:** The distinctive Gulf of Mexico shrimper prepares to lower its twin side-trawls off Alabama. *William B. Folsom, NOAA Fisheries*

today are required to have modifications—"escape vents," timed-release doors, or breakaway parts—to prevent continuous fishing if they're lost.

Some specialized kinds of traps—the small hooped nets and funnel-like fykes—are made almost entirely of netting, rather than wood or wire. The devices are anchored in a horizontal position, usually in a quiet stream or estuary, to catch bait fish, migrating eel, or other small finfish. Still other types of traps are the cylindrical plastic pots used to capture eels, and the containers used by a few southern fishermen to lure octopus.

Scoops constitute another trapping method. Pacific Northwest and Alaska tribes used scoops to intercept salmon returning upriver to spawn. Although not common today, scoop fishing worked by placing boxes or baskets along salmon migratory routes. As a salmon jumped over an obstacle placed in front of the basket or box, it landed squarely in the waiting receptacle. Before the advent of Columbia River dams, Native Americans stationed along the waterway's many falls also used long-handled scoop nets to catch salmon. Modern tribes, however, generally use conventional nets and lines to catch salmon.

TOWED GEAR

Probably the most widely recognized type of net, trawls—along with purse seines—are the workhorses of the American fishing fleet and are responsible for the greatest portion of the nation's fish and shrimp catches. No fishing method is as complex as large-scale trawling. To be on the bridge of a trawler while the net is in the water is to watch fishing as high art.

Hundreds of trawl styles and sizes are used today, but American trawls all share some common characteristics. Trawl nets are towed behind highly specialized and powerful vessels. The net itself is a long conical bag at the end of which is a mesh receptacle—the "cod end"—that can be untied to empty the fish. The opening, or mouth, of the net is spread horizontally by steel or wooden "doors" at each side, to which the tow ropes are fastened. The net is kept open vertically by a balance of floats on the mouth's top line to lift it, and sinkers on the bottom line to stretch the mouth downward. Trawl fishery targets tend to occur in large schools—shrimp, pollock, and herring—or as a mix of bottom-dwelling animals, such as groundfish and scallop.

Most trawling today is done from a single vessel, but pair trawling is occasionally done. The technique is difficult, requiring two highly coordinated vessels to tow a single net, and it usually results in a larger yield while expending proportionately less energy and fuel than single-vessel trawls. Primitive pair trawls were used in pre-Columbian times by Northwest tribes, with two rowed boats towing a small trawl for salmon. Prior to the advent of steam- and gasoline-powered engines, American trawls were pulled by sailing vessels. The last of the magnificent New England sail-powered trawlers retired well into the 20th century, and is today a fascinating tourist attraction in the historic Massachusetts fishing port of Gloucester.

Some trawl nets are deployed and retrieved directly over the stern, as with the North Pacific factory ships that have huge cranes or A-frames for that purpose. Smaller trawlers, or "draggers," often deploy their nets from booms or outriggers that extend behind or out to the side of the boat, and tow one or two nets from each boom. The side-trawl configuration is the legendary Gulf of Mexico shrimp boat. Trawl nets themselves are usually paid out and retrieved by means of hydraulic winches, but small trawls can be managed by hand, as they were aboard 19th-century trawling schooners.

Trawls are by no means always towed directly on the bottom. Frequently, their target is the great schools of fish higher in the water column. These specialized, very wide-opening nets are known as mid-water, or pelagic, trawls. This type of net is used to take Alaska's enormously valuable pollock. It often requires the use of giant curved steel spreaders (doors) that, because of their hydrodynamic design, are more efficient than the usual flat "otter board" doors.

Dredges are also used to harvest bottom-dwelling molluscs. They're really small bags, sometimes of net but more often of iron rings held together by clips and attached to a heavy steel or iron beam surrounding the bag opening. Dredges are dragged along the bottom in either shallow or deep water to dislodge scallop, clam, oyster, or flatfish. They're generally towed by vessels, but small, hand-pulled dredges are sometimes used on mudflats. The giant seagoing scallop dredges have a sharp underbar that scrapes the bottom, while other types of dredges may have rake-like teeth to uncover clams or other buried molluscs.

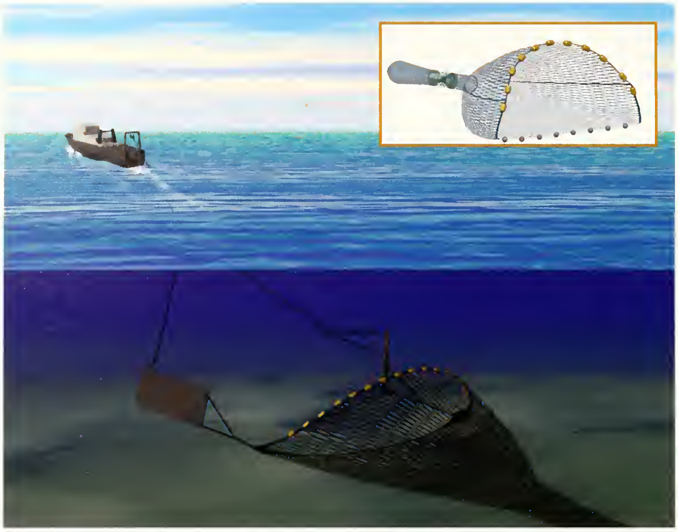
Another trawl modification, not really common in the United States except as a gear for Gulf of Mexico shrimp, is the beam trawl. Running over the sea bottom, beam trawls are used primarily for finfish, shrimp, and sometimes sponge, but not usually for molluscs. The beam trawl frame has only an upper bar and side beams to spread the net. These side beams are sometimes converted to sled-like runners, but the lower "foot" of the frame is absent. Like dredges and most other trawls, beam trawls are towed behind a vessel. Another kind, the "chopstick" trawl—imported to the Gulf Coast with the wave of Vietnamese immigrant fishermen, and now illegal—is pushed in front of the boat through shallow water by two long poles that cross as they protrude over the pilot house.

DIVERSIFYING

Bob Spaeth is one of a growing number of commercial fishermen whose economic success depends on diversifying their operations. Working out of Madeira Beach, Florida, Bob owns and operates several longliners that fish for both sharks and reef fish in the Gulf of Mexico. But other fishermen may target a different resource mix, use different gear seasonally, or even switch gear in the middle of a trip. So one can easily find a California vessel carrying not only a huge reel of salmon netting, but also miles of longlines for rockfish, and even a few trolling poles for surface-swimming salmon. Boats in the Northeast and Mid-Atlantic routinely switch from large-mesh trawls for cod and haddock to small-mesh nets for whiting and squid, while Hawaii-based vessels commonly shift between harvesting surface-dwelling tuna and deepwater swordfish.

Diversifying can also mean expanding into a new geographic area. American fishermen have always fished within rather broad ranges, to follow migrations of a preferred species or, sometimes, to pursue secondary targets. In recent years, though, as the intense competition and dwindling resources have resulted in closures and fishing trip limits, boats have routinely trekked considerable distances, as when Virginia's scallopers steam north to harvest beds in New England. But while diversifying can bring substantial profits (or at least tide fishermen over during lean periods), it brings headaches—heavy fuel and labor costs, long trips away from home, increased permitting and record-keeping—that keep some fishermen focused on a single resource near their home port.

Bob Spaeth, Madeira Beach, Florida (Lauri Lawson, NOAA Fisheries)



TOP LEFT: A trawl net rigged for fishing on the sea floor. **INSET:** Detail of trawl net with bycatch-reduction device. *Jim Bean, Communications Collective/NOAA Fisheries.* **TOP RIGHT:** A shrimp trawl net is readied for a trip out of Biloxi, Mississippi. *William B. Folsom, NOAA Fisheries.* **BOTTOM RIGHT:** A netmaker puts the finishing touches on a shrimp net equipped with devices to reduce bycatch and exclude sea turtles. *William B. Folsom, NOAA Fisheries.* **BOTTOM LEFT:** Welders work at night on an iron scallop dredge to ready it for the next day's fishing. © *Nance S. Trueworthy*

No commercial gear is modified more frequently to improve performance than towed gear. Special "kites" help keep the trawl bag open, mesh funnels and pockets improve water flow, and transducers inform the crew of the net's positioning. The bottom line may have rollers to help it move over rocky bottom, and chains or fluttering ribbons to help "kick" burrowing animals into the bag. The mesh size is critical, since large mesh will help decrease water resistance and, therefore, fuel use. Mesh that is too large will allow the target species to escape, and mesh that is too small may result in heavy bycatch that requires labor-intensive sorting (and, if discarded, is perceived by an angry public as wasteful). Trawl nets have a higher rate of bycatch than most other gears, since they retain all animals that can't pass through the mesh.

Most trawl captains would like nothing better than to have nets that eliminate bycatch without losing much of the target species. In addition to the issue of waste, the nets can clog badly with bulky sharks and skates, jellyfish, and seaweed, and the sheer weight of this stuff can make a pulp of the smaller shrimp or groundfish already in the net. Effective bycatch reduction devices (BRDs) that fit in the net have been developed for shrimp nets, but some fishermen (especially in the Gulf of Mexico) claim that the devices release too many shrimp along with the bycatch. And not all BRDs work in all trawls: the "Nordmore grate," a device that looks like a barbecue grill, is well accepted in Northeast and Northwest shrimp fisheries, but is useless where the bycatch and target species are basically the same size—as in the Gulf of Mexico shrimp fishery.

SEINES

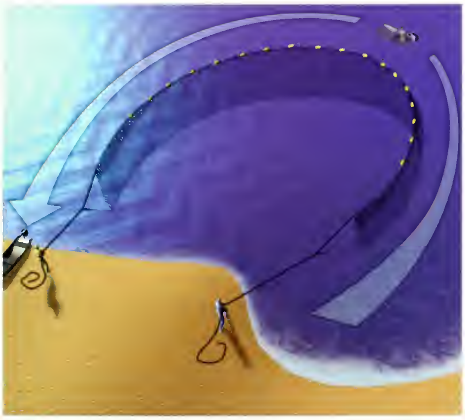
Perhaps the oldest method of taking fish in any quantity is by seining, which uses nets that surround the fish. Simple seine nets all have a "wing" on each end, to which the haul ropes ("drag lines") are attached. Many types of seines have a bag at the center to prevent the fish from escaping.

Some seines are set and hauled from the beach. Although they can be quite long, they're seldom more than just a few meters deep. In the 19th century, beach seining was common along the east coast, and rowboats crashing through the surf to set the nets were a common sight. To use a beach seine, one end of the line is held on the beach, while a small boat pays out the net in a wide arch, bringing the other end back to the beach. The lines are then hauled in simultaneously, and as the net comes ashore, fishermen have to be quick to prevent the wriggling fish from escaping back into the water. In some quiet tidal creeks and rivers, one can sometimes see another type of nearshore seine—the little "pole seines" held upright between poles to catch small fish.

Large-scale pelagic haul seining, however, uses sometimes immense nets that fish to depths of 400 meters. Such seines have very long wings and are set in a circle from a fixed place, usually an anchored boat or buoy. As the crew closes the very long towlines together, the startled fish are herded into a tight school in the net bag. The entire net is then drawn alongside the boat, where the fish are removed by large buckets or hydraulic pumps. Compared with trawl hauls, each seine set is quicker and uses less fuel.

SURROUNDING NETS

Somewhat similar to haul seines, but far more common in the United States, are lamparas and purse seines, highly specialized gear that completely circles a fish school (and anything else associated with the school, such as porpoises). These nets take advantage of the shoaling behavior of such animals as tuna, salmon, herring, squid, and mackerel. They can be used in relatively shallow water, as for menhaden, or in deep water, where yellowfin and skipjack tuna are found. These types of net are set near the surface by small boats (usually deployed from a larger, "mother" ship), with the wall



LEFT: Turn-of-the-century fishermen in Astoria, Oregon, haul seine for salmon with the aid of horse-drawn barges. *Scientific Publications Unit, NOAA Fisheries.* **BOTTOM LEFT:** A beach seine, used to take fish moving through the shoreline zone. *Jim Bean, Communications Collective/NOAA Fisheries.* **BOTTOM RIGHT:** A large herring haul seiner prepares to reel in a night set in the Gulf of Maine. *Jeffry Symonds, Northeast Fishery Science Center Observer Program, NOAA Fisheries*

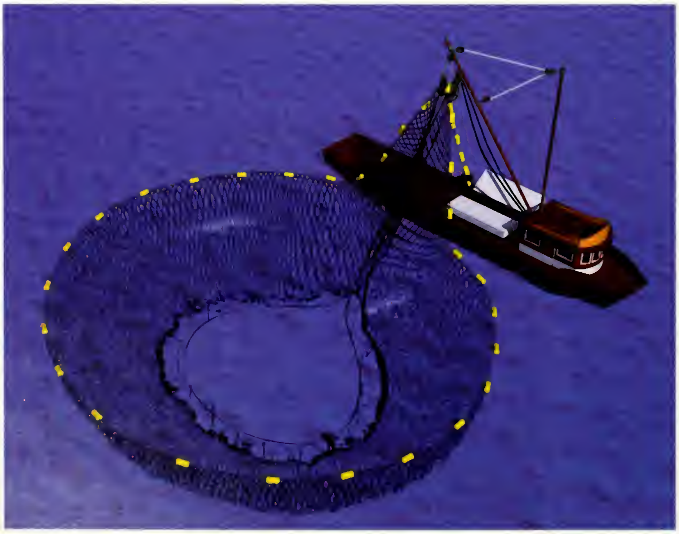
A small Atlantic menhaden boat starts reeling in the net after a successful set. © *Nance S. Trueworthy*

of net hanging down in a circle around the fish school.

The lampara originated in Italy and was brought to California in 1905 by Italian sardine fishermen. Lamparas have a bottom edge that can be pushed beneath the school of fish like a dustpan; the weighted bottom line is much shorter than the top line (float line). The wings are then brought together, concentrating the fish in the bag, and hauled to one side of the boat. Lights or loud noises help keep the fish from escaping while the wings are brought together.

Purse seines are more common—and more complicated—than lamparas, but extremely effective in catching surface-schooling fish. They're peculiarly American in origin, first used for menhaden shortly after the Civil War. A purse seine consists of a long wall of netting and a bottom line (lead line) equal to or longer than the float line. The bottom line also has heavy rings through which a "purse" line is strung. The net is set quickly around the fish school, and the purse line is then hauled so that the net is gathered like a woman's drawstring purse, and the fish can't escape. The net is hauled alongside the vessel to concentrate the catch, and the fish are then bailed out ("brailed") by hand scoops or sucked up by hydraulic fish pumps.

Purse seining is highly mechanized today. The net may be set from very large vessels or from smaller boats, like salmon seiners. With one end attached to the stern of the purse seiner, the net is managed with the assistance of one or two small boats. Perhaps the most important technological development in this fishery was the introduction of the power block, which, when hung from a derrick or crane high over the water, permits much more rapid hauling and stacking of the net. Pacific salmon seiners were the first to use power blocks, in 1953, but blocks were soon adopted by many fisheries and are vital to the tuna purse seine fishery. For smaller vessels (including today's salmon seiner), the block has for the most part been eliminated in favor of a large rotating drum that hauls the net much faster and with fewer crewmen, thus allowing for more sets—and fish—per day.

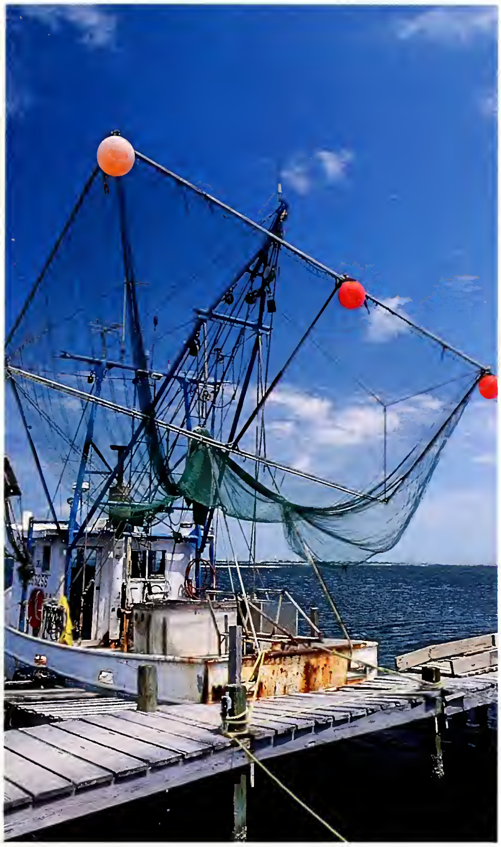


A purse seiner beginning to retrieve its net. *Jim Bean, Communications Collective/NOAA Fisheries*

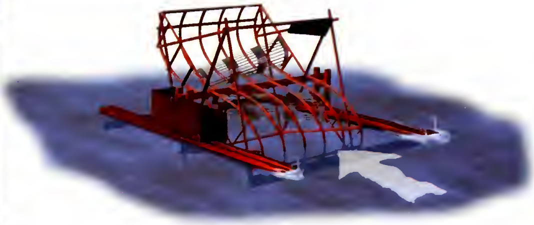
LIFTING DEVICES

Some simple types of gear work by merely lifting entrapped animals to the surface. A "lift net" is a small, baited piece of mesh attached to a lifting frame and spread flat on the bottom where a fisherman can see it. When a fish or crustacean moves onto the net, the fisherman lifts it rapidly, which presses the animal into the net and prevents its escape. Liftnets are often used for catching bait fish or crabs, especially by anglers deploying the gear from bridges and sea walls.

Another type of lifting device is the fish wheel, most commonly used by Northwest and Alaskan tribes for catching salmon as the fish migrate upriver to spawn. It's also used by nonindigenous fishermen living along such prime salmon streams as the Copper River. The device is a large water wheel that works like a car-



FAR LEFT: A small Corpus Christi wing netter prepares for shrimping in shallow Texas waters. *William B. Folsom, NOAA Fisheries.* **NEAR LEFT:** A South Carolina woman checks her bait in a simple lift-net designed for taking blue crabs. *Willliam B. Falsom, NOAA Fisheries.* **BELOW:** A mobile fish wheel that can be towed to the desired fishing spot to take migrating anadromous fish. *Jim Bean, Communications Collective/NOAA Fisheries*



nival Ferris wheel, with two or three frames or "shovels" facing the current and lifting the passing fish out of the water. Fishermen have to work quickly to retrieve the salmon before the shovels descend again into the water, or the fish may escape. Most wheels are stationary, but some are mobile and towed by boat from place to place.

Closely related are the "wing nets" used to catch shrimp along the Gulf and South Atlantic Coasts in areas with strong tidal currents. Also called "channel nets," these are shallow bags kept open by floats and lead weights, and usually anchored in a bayou or estuary. The wings are lowered into the water across the direction of the shrimp migrating out to sea, and the animals are trapped by water pressure against the nets. Smaller hand-held skimming nets, scissor-like cross sticks with a net spread between them, are also used on Pacific Northwest beaches to scoop up smelt and other small fishes.

ENTANGLING NETS

The gigantic and highly publicized oceanic driftnets that until recently stretched for miles across the high seas have tended to mold public perception of entangling nets. In fact, however, most entangling gear used in the United States today is rather small. Perhaps the best known such nets are gillnets, mesh walls kept vertical by a top float line and a carefully balanced weighted bottom edge. Often strung together to cover large areas, gillnets are set so that migrating fish become entangled as they try to swim through the large mesh. Depending on the target species, nets may be set at the surface, mid-water, or bottom.

Since they're lightweight and snarl easily, gillnets are usually used in areas with slow currents and little seaweed. The catch, whether target or bycatch, is usually dead or moribund when retrieved, and unwanted species can seldom be returned to the sea alive. Thus, the public often perceives gillnets as "too efficient" or wasteful. In actuality, though, this is one of the more selective gears because the mesh size can be so carefully selected to ensure that fish are of a uniform size. But there are still unwelcome catches—with attendant bad publicity—of seabirds, sharks, seals, and porpoises.

Gillnetting is an art: fishermen must know how various species behave at different times of the day, and when the targets might detect the nets. Success depends on the fish not being able to see the net, so the mesh is usually made of almost transparent monofilament rather than cotton or other more visible fibers, and is frequently colored to blend with the environment. Even so, fishing can be confounded by bright moonlight and phosphorescent plankton that cause the mesh to glow as brightly as a neon sign.

NETTING SALMON: A TRADITIONAL FISHERY UPDATED

Some Native American groups still use small nets to catch fish migrating up rivers. At sea, though, tribesmen hunt their targets from power boats outfitted with power winches and sophisticated electronic technology. One such group, the Tupik, works the deep-blue waters of Bristol Bay, Alaska, for its bountiful salmon.

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1 Native American crewmen put their modern vessel to sea in the chase for an ancient and honored quarry, the Alaska salmon. 2 Inside the pilot house, the skipper relies on modern communication and navigation technologies to maintain a competitive edge. 3 One experienced crew is already paying out the net, as other boats (background) arrive on the Bristol Bay fishing grounds. 4 Payday—a glistening, net-caught salmon, one of many in the day's haul that helps support this Tupik fishing family. 5 Like small-scale operations everywhere, Bristol Bay crews tend to consist of family members and close friends. *Photos by Karen Ducey, NOAA Fisheries.*

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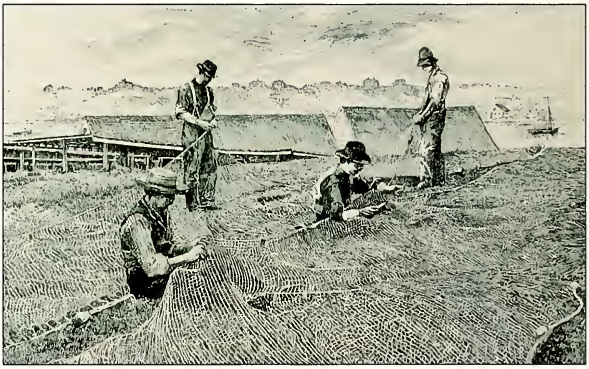
Since the net must also be very soft and pliable, it tends to tangle easily and rip; thus, gillnet fishermen spend quite a bit of time untangling and mending their gear. Large-scale gillnetting is labor-intensive, and requires hydraulic gear and power blocks for haulback. For small-scale harvesters, especially artisanal groups, this is a low-cost and fuel-efficient method, and generates higher profits than most other nearshore gear. In addition, captured fish are usually in very good condition if taken from the nets promptly, often commanding a better price than fish squashed in a trawl net.

Most gillnets today are either fastened to a drifting vessel or anchored for short periods in nearshore areas. Small gillnets may result in significant ghost fishing, however, because although the float line is made of biodegradable twine that rapidly rots and causes lost nets to collapse on the bottom, the monofilament line doesn't easily degrade and may entrap mammals, birds, and other creatures. The huge high-seas driftnets not only had a large bycatch of marine mammals, seabirds, and large fish, but the miles-long "walls of death" occasionally broke loose and became "ghost nets," continuing their devastation unchecked.

The giant driftnets were set mostly by foreign vessels, and have now been prohibited under the United Nations High Seas Drift Net Agreement of 1994. In actuality, the gear was seldom used by American vessels. In fact, U.S. salmon fishermen frequently protested that foreign driftnets took an unfair number of Pacific salmon that would otherwise have returned to American streams for spawning. But the driftnets were largely responsible for coalescing public opinion against all types of entangling gear, including small gillnets, and several states have now banned gillnets entirely.

Most other types of entangling nets aren't very selective, and have been banned from U.S. waters since 1955. One type still in use is the trammel net, which differs from gillnets in the way that fish are enmeshed. With a gillnet, the fish is caught, usually behind the gills, as it tries to swim through the single panel of mesh. With the triple-walled trammel net, the fish passes through one of the two outer mesh walls on either side of a small-mesh panel, and becomes entangled in the inner panel. Trammel nets are used primarily for bottom-dwelling species, and sometimes have a substantial bycatch of unwanted species or sizes.

LEFT: Clear monofilament netting is popular for gillnets, but tangles easily around the corks as well as fish. *William B. Folsom, NOAA Fisheries.* **TOP RIGHT:** Herring fishermen in Casco Bay, Maine, mend their gillnets in this 19th-century engraving. *From a photograph by T.W. Smillie. The Fisheries and Fishery Industries of the United States, NOAA Fisheries.* **BOTTOM CENTER:** A Makah tribesman sets gillnets for salmon in a coastal Washington estuary. *Courtesy Pacific Fishing magazine.* **BOTTOM RIGHT:** A Bristol Bay, Alaska, crewman removes a salmon caught in the mesh of a gillnet. *Karen Ducey, NOAA Fisheries*



FISH-ATTRACTION METHODS

Many fishermen depend to some degree on methods that attract and concentrate fish in a small area. At the most basic level, this is what the baited hook does. Both commercial and recreational fishermen commonly throw strong-smelling "chum" into the area—bits of fish or other animal waste, fish oil, blood, and even plant material, such as anise oil—to get the fishes' attention. Fishermen also use modern technology to concentrate fish that have a natural tendency to hide, to move toward a light or other stimulus, or to merely associate with others of their kind. For example, bait boats commonly fish at night with strong lights that attract sardines, herring, anchovies, and squid to the surface where they can be scooped up or a net can be set around them. A newer development is the use of "light sticks," the chemical lures that attract swordfish and other nocturnally active species to deep-set longlines.

Acoustic techniques are also commonly used. Some anglers claim they successfully attract fish by making thumping sounds on the bottom or sides of their boat. Commercial fisheries also make use of sound. Tuna, shark, and other predators are attracted to water sprayed from hoses, and other devices that make splashing sounds mimicking schools of prey species.

Aggregating devices go one step further. Observing that many species of fish congregate around drifting logs, seaweeds, or even jetsam from boats, fishermen have developed artificial contraptions to do the same thing. These fish-aggregating devices, or FADs, are usually anchored rafts or floats constructed of wood, cork, or plastic foam. Marked above water with flags, FADs often have attached underwater lines of waving fronds that help lure tuna, dolphin fish, bait fish, and other species to the platform. Fishermen then use a handline, rod and reel, or small net to catch the milling fish.

TOP: Yellowfin tuna school around a fish-attraction device, making them readily available to fishermen. *Scientific Publications Unit, NOAA Fisheries.* **LEFT:** A night-fishing bait boat in Ventura, California, is equipped with strong lights to attract squid and anchovies. *Willliam B. Folsom, NOAA Fisheries.* **RIGHT:** Tuna, such as the one landed by this happy angler, are often taken at platforms and other aggregating stations. © *Allen M. Shimada*

HARVESTING MACHINES

Suction pumps aboard fishing vessels are routinely used to transfer captured fish from nets or dredges into the boat's hold, and can also be used to harvest directly. For example, the California squid fishery uses strong lights to attract the animals to an anchored vessel, which then suctions them up by means of compressed air. Hydraulic-jet dredges are also used in conjunction with pumps to blast softshell clam and other molluscs from the mud bottom and move them on board by means of an "elevator" conveyor belt.

Kelp and some other seaweeds are also harvested mechanically. Gigantic harvesting barges off the Pacific Coast function like huge reapers, with massive stern cutters that shear off the top several feet of the plants. The cut material is then pulled onboard the vessel by conveyer belts, and further chopped and stored for later processing on shore.

CAST NETS

Among the many other technologies used in American fish harvesting is the little cast net seen throughout the South Atlantic and Gulf of Mexico and in Western Pacific island areas. Usually of

A skilled cast netter aims for a school of mullet off a southeastern causeway. *William B. Folsom, NOAA Fisheries*

monofilament line and only about 8–10 feet in diameter when fully expanded, this hand-thrown net requires some practice to use, but a great many anglers and commercial fishermen have become adept at it. When thrown from embankments, bridges, or boats, the cast net drops gracefully over a school of fish or shrimp, and the weighted edge drops down to snare the animals, preventing their escape. The fisherman retrieves his catch by means of a line attached to the net's center. Larger, rectangular cast nets are deployed from small boats in some indigenous Western Pacific fisheries, and require a great deal more skill for their successful use than the round cast net.

FINDING THE FISH

Most fisheries are highly competitive, and the success of captains depends on their ability to quickly locate fishable concentrations of their target. The modern vessel's pilothouse is equipped with echo-sounding fish finders and depth-detecting sonar recorders, navigational equipment, mobile and satellite radios, deck and underwater cameras, net sounders, and computers. Many large vessels today have an electronics specialist among their crew to keep equipment working while at sea, but on smaller boats, many a captain or mate has become a proficient emergency technician. In addition, vessels are frequently assisted in locating their target by spotter airplanes that relay the location, size, and species of fish schools to the vessel.

Successful surf fishing requires great skill to sense a fish strike in the rough water. © *William B. Folsom Photography, Inc.*

A modern wheelhouse is equipped with a sophisticated array of navigation, communication, and fish-finding electronics. © *Nance S. Trueworthy*

RECREATIONAL FISHING GEAR

The vast majority of anglers use variations—sometimes quite sophisticated—on the rod and reel. Recreational fishing also includes the use of smaller versions of trawls, seines, trammel nets, cast nets, dredges, rakes, harpoons, and other gear. But the tackle familiar as the fishing rod and used for recreation is ancient, going back many centuries and clearly derived from commercial or subsistence use of similar gear.

Ocean anglers, like their freshwater counterparts, use four basic methods, frequently combining them on a single trip: float fishing, bottom fishing, spin fishing, and increasingly, fly fishing. A visit to any one of America's thousands of sporting goods or specialized recreational fishing shops is an eye-popping experience. Walls, racks, ceilings, and display cases are embellished with brilliantly colored—and costly—rods and reels, and thousands upon thousands of the neon-bright lures, flies, hooks, floats, and sinkers designed to make fishing more successful, easier, safer, and sometimes, more challenging. A woman's jam-packed handbag has nothing on the tackle boxes lugged around by America's recreational fishermen. Apart from their utility in catching fish, these accouterments have another value: the making of lures, flies, and spoons and the collecting of antique rods, reels, and wicker creels are hobbies indulged in by a great many recreational and commercial fishermen.

As for the fishing rods themselves, until fairly recently most of them were made of flexible, springy woods, such as hazel or ash, or tropical woods like bamboo. Today's rods, though, are technological wonders of carbon, fiberglass, or graphite, combining lightness with strength and elasticity. The length of the fishing rod is generally related to the type of fishing, with very long ones for surf fishing, and short, thick ones for marlin and tuna. Some rods can be collapsed for easy carrying, but planes bound for tropical destinations see a good number of fishermen lovingly guarding full-size poles protected by elegant, customized carrying cases. Very few serious anglers, it seems, have only one or two fishing rods.

Fishing reels, too, have undergone a great change since their invention thousands of years ago as mere line holders. Immense reels are needed where ocean game fish "play out" for hundreds of yards behind the boat, or must be pulled up from very deep water. These are often equipped with geared devices that permit very rapid turning of the reel, and such reels are sometimes hauled electrically. As for the fishing line, there are probably as many styles, colors, and weights as there are fish species and sizes to be caught, although most line today, except for fly fishing cord, is of synthetics like nylon or polypropylene.

Fly fishing is perhaps the most artful recreational fishing method, and also one of the oldest. This legendary technique uses almost weightless artificial flies skillfully cast to a specific point on the water by a very lightweight rod. The fly-fishing reel, though, is quite simple; the art is in the cast and retrieval. Until recently, fly fishing was largely for freshwater species, but saltwater fly fishing is very popular today with both men and women, and increasingly, fishing "rodeos" feature special competitions for fly fishing.

LEFT: Dockside shops carry a wealth of modern rods to catch every target species under every condition. **ABOVE:** An abundance of mail-order gear catalogs has helped build the giant recreational fishing industry. *Photos by William B. Folsom, NOAA Fisheries*

In addition to the actual angling gear, many recreational fishing boats are equipped with an array of navigational gear, fish finders, and other electronic devices that nearly rivals what commercial boats carry. Whether all this very costly gear gives ocean-going fishermen any greater pleasure than what is afforded by a bamboo pole along a quiet bayou or creek is debatable. Wherever it occurs, saltwater angling remains one of the most popular recreational pastimes in America, enjoyed by millions of men, women, and children. In fact, it is claimed with some credibility that the total U.S. investment in saltwater angling—including boat costs (purchase, rental, or charter), fuel costs, lodging and meals on angling trips, and, of course, bait and gear—actually exceeds the total costs incurred for commercial fishing.

LEFT: A youthful angling enthusiast in Pt. Pleasant, New Jersey, checks out the action on her spinning reel. *Edward J. Pastula, NOAA Fisheries.* **RIGHT:** Fly fishing in Pacific Northwest waters attracts thousands hopeful of taking home prize steelhead and salmon. © *Index Stock/Charlie Borland*

Andrew Wyeth
Detail from *Lobsterman's Ledge*
Ailsa Mellon Bruce Fund
Photograph 1998 © Board of Trustees, National Gallery of Art, Washington

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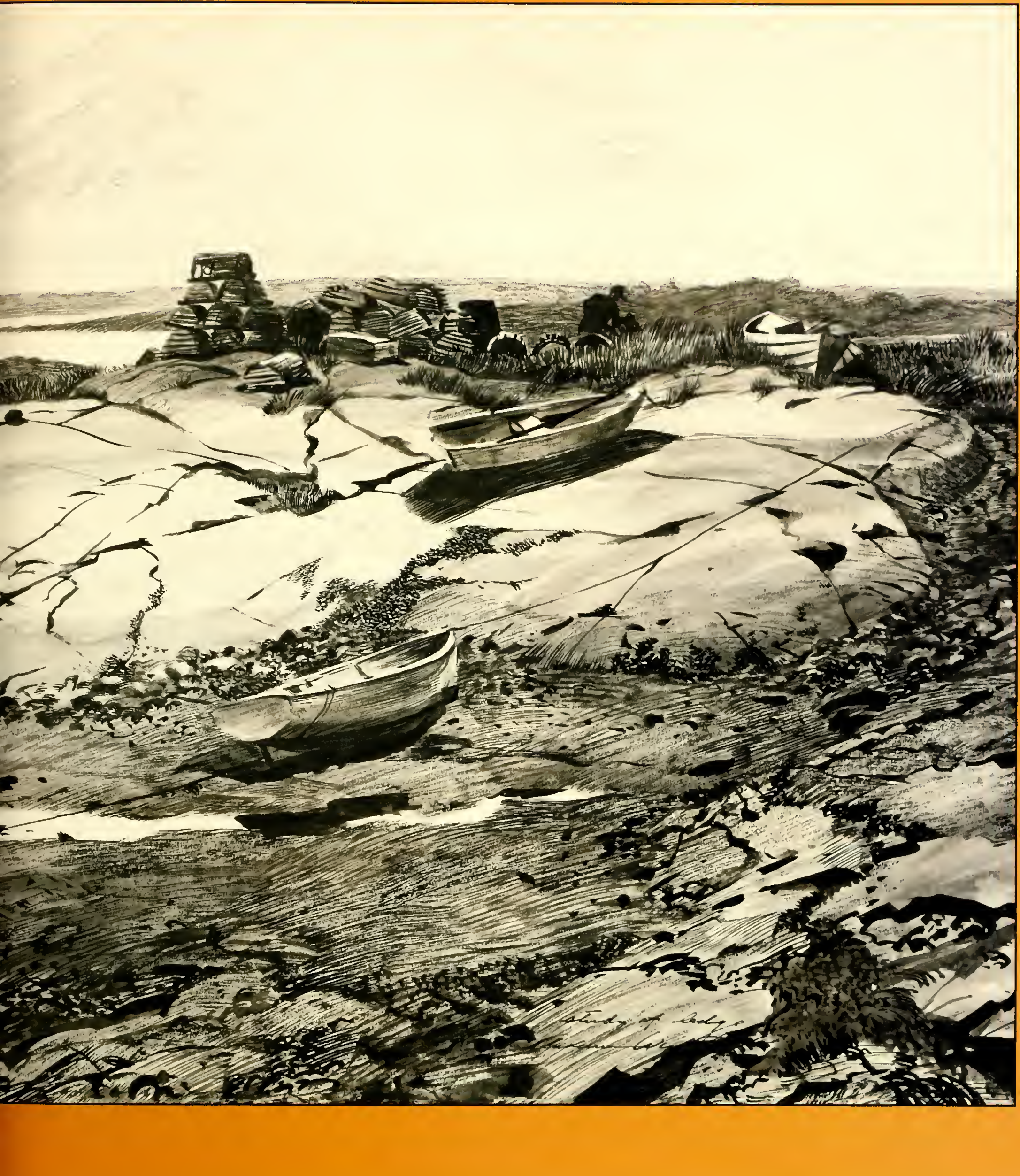
THE ATLANTIC BOUNTY


study of ledge

The Atlantic's great fisheries resources were an important factor in America's colonization and growth, and to this day are vital to hundreds of towns on the east and Gulf of Mexico coasts. This section describes the region's major fisheries—their history, the environment that has shaped them, and the problems besetting them.

THE ATLANTIC REALM

Atlantic America is indeed Neptune's banquet hall. Many of the region's species are found along a very broad stretch of the coastline, and some, such as king and Spanish mackerel, extend around the tip of Florida into the Gulf of Mexico, and beyond into the Caribbean. Except for the offshore, highly migratory species—tuna, swordfish, marlin, and some pelagic shark—harvested stocks tend to fall primarily into one or two of five zones: the Northeast (New England), Mid-Atlantic, South Atlantic, Gulf of Mexico, and Caribbean. Not coincidentally, each zone corresponds with one of five Atlantic Regional Fishery Management Councils. Thus, although the "Maine" lobster is also harvested as far south as North Carolina, it's primarily a New England fishery and, thus, managed by that Council. However, several resources—such as summer flounder, oyster, blue crab, bluefish, and mackerel—are harvested in several zones, and may be managed by the state or federal government or by both.

The Atlantic realm: blue seas, white sand. *William B. Folsom, NOAA Fisheries*

The geographic terms used here are meant to refer to those portions of the Atlantic touching U.S. shores. For example, "South Atlantic" refers to the Southeastern states and not to the broad-scale (and more accurate) application as the Atlantic region south of the equator.

Atlantic fishery resources—whether nearshore or offshore, in Maine or Mississippi—share a life dependency on a single transcendent ocean feature: the Atlantic "conveyor belt." This massive current system, made from both the warm-surface Gulf Stream and its associated North Atlantic Current, and the cold North Atlantic Deepwater Current, is the symphony to which the coast's ecosystems waltz. Along the shoreline, the Gulf Stream generally flows southward. Offshore, it flows north and becomes the North Atlantic Drift, with a large branch off the Mid-Atlantic circling to West Africa and rejoining the Gulf Stream off Venezuela. Moving swiftly at almost 7 miles per hour, this 50-mile-wide "river" meanders and shifts, sometimes breaking off into coastal water masses. In the shallow Gulf of Mexico, it forms the Loop Current that allows for the great productivity supporting the region's warmwater—almost tropical—fisheries.

As the equatorially heated Gulf Stream drifts north, constant evaporation makes surface water saltier and, thus, denser. When these salty waters reach Greenland and Iceland, they begin to cool and sink,

FACING PAGE: Atlantic tarpon. © *Tim G. Simas, Clear-Water Images*

TOP LEFT: Stormy Atlantic seas are common, but seldom a reason for not going fishing. *Commander Craig N. McLean, NOAA.* **BOTTOM LEFT:** South Atlantic rough seas and strong winds took their toll on this boat in Folly Beach, South Carolina. *William B. Folsom, NOAA Fisheries.* **RIGHT:** The climates of South Florida and the Caribbean favor tropic-loving mangroves, like these in the Florida Keys. *William B. Folsom, NOAA Fisheries*

forming the North Atlantic Deepwater Current that flows south along the margins of North and South America. There is growing concern that global warming may suppress this orderly circulation, with serious but unpredictable effects on the marine ecosystem and its fisheries resources.

Although the warming "El Niños" of the Pacific—which can cause sweeping shifts in fisheries' distribution—don't greatly moderate the patterns of Atlantic fisheries, they often have a noticeable indirect effect. The signature strong Pacific Jet Stream winds track across the southern states to the eastern seaboard, bringing heavy storms that destroy property, cause flooding, toss boats around, and make seas too rough for fishing. It's difficult to pinpoint these weather conditions as being specifically El Niño events, however, since they also occur in the absence of El Niño.

The sweeping Gulf Stream not only nourishes an extraordinary number of oceanic species, but also tempers the climate of the entire east coast. The Gulf Stream is nearest land—only a few miles off the coast—at Palm Beach, Florida, and falls away as it flows north until it's about 100 miles offshore. During the summer, frontal zones forming between warm offshore and cold inshore currents allow for mixing of these water masses; one of the happy results is the often excellent fishing in this area. The current's meandering can also lead to dramatic changes for fisheries

Snow-covered lobster pots are a common winter sight on coastal Maine docks. © *Nance S. Trueworthy* resources—for example, when water-mass shifts strand tilefish in fatally cold water.

Though the influence of these giant currents is profound, it certainly doesn't contribute to a uniform climate in the Atlantic. Enormous differences in both terrestrial and ocean features (including other currents) result in strikingly divergent climates as one travels from north to south. The same January day will see a pile of Maine lobster traps frozen solid to the dock and thousands of "snowbirds" exuberantly angling under a blistering Miami sun. In the Caribbean, however, temperatures vary by only a few degrees over the entire year, making for a more uniform fisheries environment but also precluding the seasonal fish migrations that support large fisheries in more temperate waters.

The entire Atlantic Coast is also subject to murderous winds, fierce thunderstorms, and devastating hurricanes. The New England and Mid-Atlantic shores suffer as well from hailstorms, ice-covered bays, snowdrifts, and sometimes savage northeasters—winds blowing onto land from the North Atlantic. And the Southeast faces other kinds of severe weather in the form of downpours, superheated shallow waters, and waterspouts.

If the Atlantic's major oceanographic feature is the Gulf Stream, perhaps its primary physiographic feature from the fisheries standpoint is the continental shelf. The shelf is relatively wide on the east coast, an important factor in the development of so many fisheries. It's wider still in the Gulf of Mexico, but quite narrow around the Caribbean islands. In most areas, therefore, fishermen haven't had to go very far from shore to reach productive fishing grounds. For the early colonists, this was a great—and welcome—change from the distant grounds that characterized fishing in the Old World. The shelf, with depths to about 600 feet, tapers to a narrow band off Florida. Off New England, though, it encompasses the Gulf of Maine and such rises as Georges Bank and Grand Banks—historically some of the North Atlantic's richest fishing grounds.

South of these great banks, two large ocean areas also contribute to the productivity of Atlantic fisheries. The Mid-Atlantic Bight extends from Cape Hatteras north to Cape Cod, and includes the largest protected body of salt water in the United States: Chesapeake Bay. The other area, the South Atlantic Bight, encases fisheries from North Carolina to southern Florida.

The entire Gulf of Mexico, on the other hand, is more like a bowl-shaped Mediterranean Sea. It is totally enclosed, except for the narrow Yucatan Channel connecting the Gulf with the Caribbean Sea on the south, and the equally narrow Straits of Florida connecting it to the Atlantic Ocean on the east. Its continental shelf and slope are covered with salt domes, ridges, mounds, basins, and reefs that form an extremely irregular bottom topography, and the adjacent land mass is fringed by an almost continuous array of bays, inlets, lagoons, and marshes. The Gulf has one extraordinary feature that is a major contributor to its fisheries' productivity: the Mississippi River, whose delta over the eons has been enriched by fertile silts washing down from its vast drainage area.

The Atlantic and Gulf of Mexico Coasts almost everywhere abound with the tidal marshes that are vital for fish and shellfish spawning and nursery areas. At the boundary between water and land, the fields of seagrass are locked into cycles of growth and decay that make up the rich soup nourishing fishery resources. Not all marshes have identical roles, values, or levels of productivity, of course, but each contributes to the region's wealth of seafood. South of New Jersey, most of the commercially important fish and shellfish are dependent to some degree on salt marshes. In New England, though, some of the most highly valued fisheries resources—for example, cod, haddock, and some flounder—spend their

LEFT: Port Isabel is one of many Texas towns with good harborage and ready access to the Gulf's famous shrimp stocks. *William B. Folsom, NOAA Fisheries.* **BELOW:** Cedar Key, Florida, is home to thousands of fishing boats and small craft, as well as large shrimpers and luxurious cabin cruisers. *© Index Stock/Timothy O'Keefe*

This productive marsh in Moss Point, Mississippi, is only one of thousands in the Gulf of Mexico. *Lauri Lawson, NOAA Fisheries*

entire lives out in the Gulf of Maine or on the great offshore fishing banks, and never directly inhabit marshlands. However, many of these "offshore" species depend on forage species—crabs, herring, and other fishes—that are themselves estuarine-dependent. In southern Florida, and in the Caribbean which has fewer wetland areas, mangroves and nearshore coral reefs serve as nurseries for many finfish and shellfish species. Central and North Florida, on the other hand, are awash in swamps and marshes, and almost all of South Florida is a vast tropical prairie—the Everglades.

Almost everywhere, the rivers that give rise to these wetlands have another major fisheries role. Many Atlantic species are termed "anadromous"—that is, they spend most of their life in salt water, but migrate into the region's many freshwater streams to spawn. (In a turnabout, the "catadromous" American eel spawns far out at sea, and moves into rivers and streams for its adult life.) The migration of striped bass, Atlantic salmon, alewife, river herring, rainbow smelt, sturgeon, and shad into shallow streams was well understood by both Native Americans and colonial settlers, and was seized upon as an easy way to fill basket and larder.

Other habitats also offer food and refuge to Atlantic fisheries resources and determine what fishing gear must be used. For example, countless lobsters inhabit Maine's rocky shores and weedy inlets, where pots and traps are needed to take the resource. The submerged sand plains and open ocean waters from Maine to Texas see the use of a great many gears: trawls and seines, longlines and gillnets, traps and dredges, rod-and-reel and scuba. But even where a gear is effective, it sometimes can't be used: gillnets have been outlawed in Florida, and many other localities and fisheries also restrict the use of certain gear.

Some Atlantic habitats have been given status as National Oceanic and Atmospheric Administration (NOAA) national estuarine reserves and ocean sanctuaries. The sanctuaries are often extensive areas so rich in biological or cultural resources that they need special protection and management. There are currently four such designated areas in the region: New England's Stellwagen Bank; the Florida Keys; Texas' Flower Garden Banks; and the *USS Monitor,* off North Carolina. Sanctuary designation affords protection from certain kinds of exploitation and development, while still permitting fishing and boating in most areas. The estuarine reserves, smaller inshore areas, also afford

Many Atlantic fisheries resources depend on salt marshes, like this one in Beaufort, South Carolina. *William B. Folsom, NOAA Fisheries*

protection against unregulated shoreline development or use.

Lying 1,100 miles southeast of Miami, America's Caribbean territories provide a quite distinct fishery environment. Puerto Rico and the U.S. Virgin Islands—St. Thomas, St. Croix, and St. John—are among the smallest islands in the cluster known as the Antilles. The islands rise from relatively shallow submerged banks and have very narrow shelves—in some places, the 600-foot line is scarcely more than a mile from shore. There are productive shelf areas and banks, as well as cays, small islets, and reefs, and the Mona Passage at the western end of Puerto Rico offers deep water with an abundance of large fish. Because the islands' coastlines are dotted with coves and lagoons offering safe harbor for small fishing boats, fish are landed on almost every mile of coastline. The islands have another advantage for fisheries, which is related to both geography and labor availability: they're ideally located to receive oceanic transshipments. In fact, Puerto Rico is the primary site of the nation's Atlantic tuna canneries, processing imported yellowfin and albacore tuna shipped from all over the Atlantic—and even the Pacific—Ocean.

Tropical seas don't have the great mixing of nutrient-rich water layers common to more northerly latitudes and are generally far less productive—hence, their crystalline, neon-blue appearance. In addition, heavy swells and rough seas are common along the islands' north shore, although the southern coasts are calmer and more favorable for fishing. One problem common to the myriad Caribbean islands is that they share many of the same fisheries stocks, and overfishing in one area can seriously

LEFT: Bays and sounds around Nag's Head, North Carolina, provide nurseries for hundreds of marine species. *Edward J. Pastula, NOAA Fisheries.* **BOTTOM LEFT:** Maine lobsters favor the quiet waters of the state's many rocky coves, including this one in Rockport. *© William B. Folsom Photography, Inc.* **BOTTOM RIGHT:** The deep Mona Passage off Puerto Rico's western end favors fish larger than those found among shallow-water corals. *William B. Folsom, NOAA Fisheries*

St. Thomas' Hull Bay shelters small boats, but local overfishing has meant the need to fish farther out. **INSET:** Mangrove strut roots and rooted seedlings create new habitat for young snook, snapper, and other important species. *Photos by William B. Folsom, NOAA Fisheries*

jeopardize fishing elsewhere. Some species may even migrate from distant waters, including the Amazon Basin, with unfavorable distant conditions adversely affecting U.S. Caribbean fisheries.

A SHIFTING ENVIRONMENT

America's growth has left a sinister legacy for Atlantic estuaries—and fisheries that depend on them. Industrial, residential, and farmland pollution and dredging-and-filling activities have spewed out a witch's brew of wastes and toxic chemicals that threatens the viability of regional fisheries. Stringent enforcement of the 1972 Clean Water Act has created an improved outlook for both humans and marine resources, but serious localized problems still jeopardize humans as well as fish. Particularly troublesome are "blooms" of organisms—algae, dinoflagellates, and diatoms—that cause outbreaks of serious illness in people eating fish affected by these organisms, such as neurotoxic, paralytic, or amnesiac shellfish poisoning. And the damage isn't limited to nearshore areas. Some

LEFT: Although they're rare, oil leaks and fires, like this burning well off Louisiana, are a threat to fisheries. *Richard Hartman, Office of Habitat Conservation, NOAA Fisheries.* **RIGHT:** An environmental scientist works to reduce seafood-borne illness that could cripple coastal economies. *William B. Folsom, NOAA Fisheries*

A friendly face belies the damage done by the other end in polluting coastal waters. © *William B. Folsom Photography, Inc.*

offshore clam beds that were once the dumping grounds for hazardous chemicals must be kept permanently closed for the many years it will take the clams to rid themselves of the toxins.

Until recently, local fishermen felt helpless against the far more politically powerful industries polluting shoreline waters. Now, however, where such contamination has led to closures of whole areas, some fishermen suffering lost income are demanding corrective action. One such case, which exploded in the popular media during the writing of this book, concerns warm-weather blooms of a microscopic plankter, a dinoflagellate dubbed "the cell from hell." The organism is believed to be the culprit in massive fish kills of menhaden and other fish in North Carolina's Pamlico–Albemarle Sounds and, most recently, tributaries of Chesapeake Bay. These *Pfiesteria piscicida* outbreaks may be linked to increasingly heavy runoff of waste from swine and poultry farms, much of it applied as fertilizer on farm fields. The mechanism by which this killer cell turns toxic when both heavy nutrients and some species of fish are present isn't understood. There is wide disagreement about how to reduce this nutrient load from a farm industry whose economic value is far greater than the fisheries it may damage. Control of some sort is probable: alarmingly, *Pfiesteria* may also cause lesions and neurological damage to watermen, shellfish-bed inspectors, and boaters working in the area of these very brief (3–4-hour) but ruinous outbreaks.

Greater government scrutiny and technological advances may help mitigate the damage to productive wetlands, with concerned government agencies actively encouraging innovative cleanup technologies. Methods have been developed to nullify the effects of petroleum hydrocarbons, pesticides, and other residues of a more permissive—if poisonous—era. And perhaps more important, the 1996 Magnuson–Stevens Act continued provisions to allow federal fisheries managers more opportunities to comment on proposed coastal development.

FROM THE EARLIEST DAYS ...

From its very beginning, much of the nation's commerce centered on fishing and seagoing activity. The English explorer John Cabot reported great numbers of "baccalao" (cod), "tunnies" (tunas), salmon, and seals off Newfoundland, leading to occasional cross-Atlantic fishing ventures to the New World fishing grounds in the 16th and 17th centuries. America's nearshore resources, of course, had been harvested by indigenous people long before the arrival of European settlers.

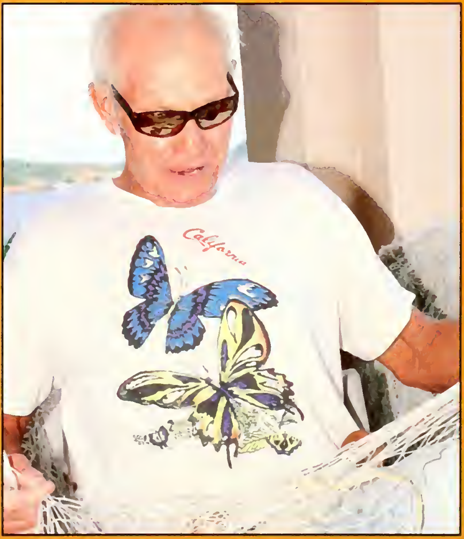
John White, an artist later associated with the famed Captain John Smith, sketched Mid-Atlantic tribes' ingenious harvesting methods in 1590. Reports of the abundant fish fauna also helped lure English colonists to the New World. White's detailed drawings of various

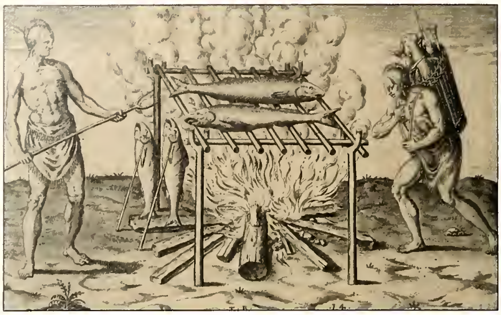
AN Eye ON THE PAST

Joe LaPlace is only one of thousands of commercial and recreational fishermen whose memory of a better fishing environment has pushed them into conservation activism. Joe, who has been fishing for more than three quarters of a century in St. Thomas, U.S. Virgin Islands, fondly recalls an era where fishing was almost exclusively by local inhabitants working the islands' crystalline coves and bays. As elsewhere in the country, though, a dramatic increase in the number of professional fishermen has led to heavy, often indiscriminate harvesting, often by large enterprises with little interest in the local economy. As a result, local fishermen are making longer and longer trips to catch fewer and fewer fish.

However, fishermen aren't known for their indifference—or their reticence—in expressing their views, and the industry's "old timers," especially, have proved to be some of the most influential voices in the fishery management process. Theirs is a perspective that is especially valuable, for it sees the community's traditional needs, as well as the technologies and economic realities that drive today's fisheries. They have a strong sense of where and how large the fish used to be, when they should be left alone to spawn or grow, and when too many fishermen are harvesting the stocks. And when this institutional memory has gone, fisheries will beat with a different—perhaps smaller—heart.

Joe LaPlace, St. Thomas, U.S. Virgin Island (William B. Folsom, NOAA Fisheries)





Thomas Harriot's 1590 depiction of Virginia's fish bounty encouraged British emigration to the new land. *Library of Congress, illustration by John White in A Briefe and True Report of the New Found Land of Virginia, by Thomas Harriot, 1590*

Indian traps, weirs, spears, and the shallow-draft canoes clearly show the inspiration for many fishing methods adopted by the colonists.

It was left to the early English and Dutch settlers in New York and New England, whose Old World diets were rich in oysters, eels, and herring, to set about routinely harvesting the waters of their new home. Highly organized Dutch fishing companies had firmly dominated European waters, sometimes even shutting out the British along their own coastline. And the ready availability of fish and shellfish in America was seen by England as a way to expand its sovereignty. Although most settlers were actually farmers by trade, it was fishing that became the first real commercial enterprise of the American colonies. Along with cod, herring, and shad, many other resources were taken in substantial quantities—mackerel, mussel, whelk, lobster, limpet, squid, and capelin—and colonials soon expanded their fishing to take the hordes of great whales that roamed the North and South Atlantic Oceans.

Captain John Smith himself had enthusiastically described, in 1614, the region's great abundance of edible sea creatures. More detailed accounts in the 17th century noted immense stocks of swordfish, alewife, salmon, mussels, bluefish, and 59 other species of edible marine animals.

Early Spanish and French settlers of the Atlantic also harvested marine species and conducted an extensive trade in them with the natives. Indigenous peoples everywhere along America's coasts depended heavily on fish and shellfish, using dugout canoes to spear and net a large variety of fish, setting fyke nets along inlets and in coastal streams to trap migrating fish and shrimp, and collecting oysters from the abundant natural beds.

Unfortunately, knowledge of early colonial fisheries in U.S. Caribbean territories is sparse, since records maintained by the Spanish government weren't available when the United States assumed control of Puerto Rico in 1898. Under the Spanish regime, exclusive rights were granted to fish in productive areas close to river mouths and on various beaches known to be good sites for haul seining. These rights were sold at auction to the highest bidder, but all fishermen who obtained a license were forcibly enrolled in the reserve force of the rather quarrelsome Spanish navy—possibly a good reason not to openly engage in fishing. Shortly after Puerto Rico became a U.S. territory, exclusive fishing rights were abolished by official order.

As for the South Atlantic, intensive commercial fishing occurred far later than in the Northeast—not until the 19th century. As in New England, fisheries growth also meant an influx of new workers, this time a wave of Slavic, Italian, and Greek immigrants who joined freed black slaves and, in the northern Gulf of Mexico, descendants of the French-speaking Acadians ("Cajuns"). Entire families worked long hours in the Mississippi and Louisiana fisheries, the small children perched barefoot on wooden crates to shuck shrimp and oysters in steaming sheds. Their Northeast cousins hardly had it better, though, crowded into freezing barns to salt down herring and cod, and fill

The bream and sturgeon, drum-fish, and gurnard,
The sea-bass, which a prince would not discard,
The cod and salmon, cooked with due regard,
Most palatable.

The black and rock fish, herring, mackerel,
The haddock, mossbanker, and roach, which fill
The nets to loathing; and so many, all
Cannot be eaten.

And thus it happens here, that in the flood,
Which, rolling from the Fountain of all God,
O'erwhelms weak mortal man with royal food,
He is forgotten.

You've weak-fish, carp and turbot, pike and plaice;
There's not a pool or tiny water-trace
Where swam not myriads of the finny race,
Easily taken.

Crabs, lobsters, mussels, oysters, too, there be,
So large that one does overbalance three
Of those of Europe; and in quantity,
No one can reckon.

The tortoise, seal, and shark; and, in your bay,
The mighty whale and porpoise, sporting, they
The power, and wondrous works of God display,
For our beholding.

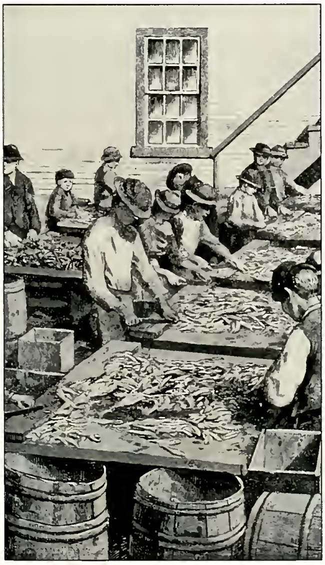
–Jacob Steendam, *Praise of New Netherland*, 1661

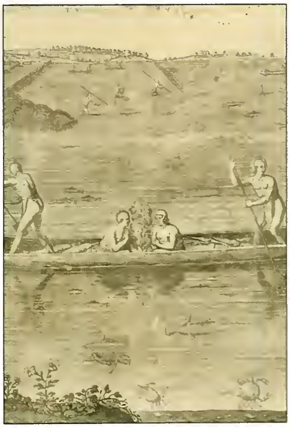
tins on the nation's earliest canning lines. And along the Florida Gulf Coast, households of Greek immigrants sorted and cleaned the sponges brought from crystalline lagoons, at first by free diving, and later in the 19th century by hard-hat divers equipped with surface-supplied air.

But from the earliest days and just about everywhere, conflicts over fishing rights have existed, with fishermen alleging that their neighbors poached, engaged in wasteful practices, and undercut prices. Not unlike today, though, some of these grievances were made primarily to eliminate competitors, rather than out of genuine concern about overfishing.

LEFT: Still a common food fish, herring are also salted for lobster bait here in Pt. Judith, Rhode Island. *William B. Folsom, NOAA Fisheries.* **RIGHT:** The humble little alewife helped feed early America, and still provides welcome fare during its spawning runs. © *William B. Folsom Photography, Inc.*

By the mid-19th century, groundfish, striped bass, Atlantic salmon, alewife, and shad were noticeably scarcer in some areas, and the battle was on to outlaw certain fishing practices. The year 1871 saw Massachusetts and Rhode Island schooner captains petitioning state legislatures to prohibit onshore traps and pounds, viewed as capturing fish in too great numbers. And an amazingly insightful 1872 report by the Commissioner of Fish and Fisheries attributed a decline in food fish to several sources: excessive overfishing and the use of "improper apparatus," pollution from "manufactories," natural variability in the abundance and distribution of stocks, and predation by other fish. These conclusions are in overall agreement with those of modern scientists. And many of the measures suggested in the 19th century are still among the methods used today for groundfish regulation: short closures to some gear types during spawning migrations, and limitations on who may be licensed to catch fish.





LEFT: Nineteenth-century Maine children found ready employment preparing sardines (small herring) for canning. *From a photograph by T.W. Smillie, The Fisheries and Fishery Industries of the United States, NOAA Fisheries.* **CENTER:** Colonists were lured to America by both the abundance and the variety of fish and shellfish. *Library of Congress, illustration by John White in A Briefe and True Report of the New Found Land of Virginia, by Thomas Harriot, 1590.* **RIGHT:** Florida's sponge industry supplied an important product to 18th- and 19th-century America. *From a photograph (photographer unknown), The Fisheries and Fishery Industries of the United States, NOAA Fisheries*

THE FISHERIES

Atlantic fisheries have been well known to generations of Americans through a rich literary tradition of both fiction and adventure stories. Atlantic whaling inspired the Herman Melville classic *Moby Dick,* and fishing is the theme of such modern-day novels as James Michener's *Chesapeake,* Peter Benchley's *Jaws* and *Beast;* Ernest Hemingway's *The Old Man and the Sea,* John Casey's *Spartina,* and Peter Matthiessen's *Far Tortuga.* Fishing is also the stuff of such best-selling mystery writers as Carl Hiasson and James Lee Burke. As this book was being written, Sebastian Junger's true-life adventure *A Perfect Storm* was on the best-seller list. Other notable nonfiction includes William W. Warner's *Beautiful Swimmers,* John Frye's *The Men All Singing,* and Mark Kurlansky's *Cod.*

Female writers are scarce in this field, although a few have made impressive contributions to works about the need for aquatic conservation (for example, Rachel Carson's *The Silent Spring* and *The Sea Around Us).* Literature drawing on fisheries is markedly short of female writers, largely because women were actively discouraged, until recently, from getting the onboard experience that lets people "write what they know." This masculine world and the values that formed it are changing, however. Today's fisheries problems require greater expertise in economics and sociology—fields with relatively larger numbers of women. Change is also coming about as a result of determined efforts by state and federal agencies to actively involve women at high levels of fisheries management. As it turns out, there are problems enough for everyone brave enough to enter the fray.

For a long while in the nation's history, fisheries problems meant Atlantic problems—or even more narrowly, New England problems. Since colonial days, Northeast fishermen have complained of too many newcomers, encroachment by foreigners or other fishing gear, wasteful discarding, and unfair or corrupt practices by buyers. And the fish buyers in return have charged fishermen with depleting the resources, providing poor-quality products, and lacking loyalty to the buyers. Increasingly, many of these problems—overfishing, overcapitalization, waste and bycatch, user conflicts, and foreign competition—are mirrored in the growth of fisheries elsewhere in the Atlantic and, indeed, throughout the country.

Mending nets usually falls to the same people who set them, like this fisherman in Pt. Pleasant, New Jersey. *Edward J. Pastula, NOAA Fisheries*

Of these issues, overutilization of fish stocks has received the greatest notoriety. It is the single greatest problem in terms of sustaining yields for future generations of fishermen. A few stocks are so badly depleted that some experts question whether they can be rebuilt to former levels without a complete halt to fishing. And many conservationists believe that those who contributed to overfishing should bear the financial brunt associated with rebuilding stocks, even if they're put out of business as a result of closures. The fisheries manager must find a way to permit some level of harvesting that will let fishermen earn a living while still allowing the stocks to recover.

The majority of east coast stocks aren't in jeopardy, of course. At the time of this writing, estimates are that about 41 percent of America's Atlantic stocks (here excluding nearshore species) are below their long-term potential—that is, greater fisheries yields could be achieved by rebuilding overfished resources, decreasing bycatch, and reducing excess capital in the fisheries. About 40

LEFT: New Bedford, Massachusetts, was the major whaling port in 19-century America. **RIGHT:** The unrefrigerated 19-century halibut schooners meant fishermen had to quickly dress the fish on board. *From photographs by T.W. Smillie, The Fisheries and Fishery Industries of the United States, NOAA Fisheries*

LEFT: Increased consumer demand may be having an impact on the stocks of Atlantic dolphin fish (mahi mahi). *Edward J. Pastula, NOAA Fisheries.* **RIGHT:** The ready availability of some local seafood makes it hard for consumers to believe accounts of overfishing. *William B. Folsom, NOAA Fisheries*

percent of Atlantic stocks are overutilized, about 25 percent are fully utilized, and about 6 percent are considered underutilized. For the remainder of the stocks—about 29 percent—there isn't enough scientific information to determine the level of utilization.

If the condition of Atlantic stocks and, in turn, the effect on coastal community health have been important issues, another industry headache not too long ago tyrannized Northeast fishermen: manipulation of the fish market. Monopolies and unfair competition among Boston and other New England buyers and middlemen were longstanding and well-known for generations. But New York's Fulton Fish Market raised iron-fisted domination to a high art. For much of Fulton's existence, a few individuals controlled the unloading, buying, pricing, selling, and shipping of fish when New York City was a major Atlantic fisheries market. Happily, New York's successful prosecution of anti-racketeering laws has begun to eliminate these problems, abetted by new marketing structures that have made it unnecessary to centralize fish marketing in New York City.

Commercial Atlantic fisheries have a centuries-old history, but large-scale recreational fishing is only decades old. The 1970s and 1980s, especially, saw a phenomenal increase of saltwater angling by American men and women of all ages, just about everywhere on the Atlantic and Gulf Coasts. As a result of this growth, fishery managers today must carefully weigh how both nearshore and offshore stocks are allocated between commercial and recreational sectors. This book's more detailed look at commercial fisheries reflects only the relatively more bountiful and complex history of that sector; it doesn't intend to suggest that recreational harvests are less important to Americans.

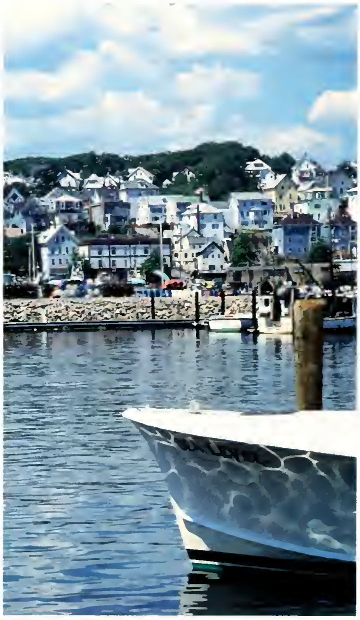
This chapter explores in more detail the major Atlantic fisheries, in terms of both their value and the number of people who work in them. It also includes several smaller fisheries, some with only a few people or a few boats. The fisheries are organized around the resources themselves, and not the somewhat artificial geographic boundaries of those who harvest or process them, the agencies that manage them, or the gear used to catch them. The groupings—for example, "groundfish"—generally describe a common niche within the marine ecosystem. But each grouping may be fished differently in different regions. Thus, one sees both Northeast and Southeast shrimp, and so forth. Finfish are presented first, followed by invertebrate and seaweed fisheries.

Northeast Groundfish

Probably no fishery has achieved greater notoriety than Northeast (New England) groundfish. America's first commercial fisheries were for cod, taken nearshore with seines and handlines primarily to satisfy local needs. The species has almost mythical status in New England. Colonial Americans who made their fortunes in any aspect of the fish trade were derisively referred to by Boston bluebloods as the "codfish aristocracy," but this didn't stop respectful politicians from placing a wonderful sculpture of the icon atop the Massachusetts State House in Boston.

Although many of the stocks making up this fishery are seriously depleted, they still bring fishermen somewhere around $115 million a year. The groundfish resource is actually a complex of 35 species living together on or near the bottom of the sea. In northeastern waters, the cod family dominated—cod, haddock, hake, pollock, and whiting—but there are also flounder, ocean perch, and increasingly, dogfish, shark, and skate. Mid-Atlantic groundfish takes, on the other hand, are primarily summer flounder (fluke), scup, monkfish (goosefish), whiting, and black sea bass. Many of the species, especially cod, haddock, and several flounders, are favorite restaurant items, but the grotesque (yet very tasty) monkfish has also found a place on epicurean lists. Because of the great demand, however, and because many domestic stocks are at low levels, much of this fare is imported today. Some species—cod and summer and winter flounder—are also very

Massachusetts' Gloucester has a long history of whaling, fishing, and shipping. *Nance S. Trueworthy, NOAA Fisheries*



important to the Northeast recreational fishery.

For most of America's history, groundfish were taken by American and European boats fishing the nation's waters, although prior to America's separation from England at the end of the 18th century, U.S. and Canadian fishermen shared the resources of British-held northwest Atlantic territorial waters. As colonial fishermen found that cod were available most of the year, unlike the strictly summer cod fisheries of Europe, they developed an industry to export superior-quality dried, salted cod to England. Lower-quality fish were also harvested, but were generally sent south as cheap food for slaves.

By the 19th century, the cod fishery also included large trawling schooners, little longlining dories, and ingenious fish traps ("pound nets") along the shoreline. The industry was then centered in Boston, Gloucester, and New Bedford in Massachusetts, and in Portland, Maine. Today's primary ports are Gloucester, New Bedford, and Chatham, Massachusetts; Pt. Judith, Rhode Island; and Portland. Groundfish are landed in many other ports, however, extending as far south as Wanchese, North Carolina.

During the 19th century, the groundfish fleet expanded to include haddock and pollock, and the large trawl bycatch of Atlantic halibut gave rise to a special handline fishery for that giant flatfish. It wasn't until the advent of otter trawls and fuel-powered vessels, along with 20th-century freezing technology, that trawls became the dominant groundfish gear. Trawling still reigns, but groundfish are also taken by gillnets (especially in the Gulf of Maine), longlines, and traps. In one specialized fishery, North Carolina summer flounder (fluke) are "gigged" (speared) from shallow-draft boats plying the state's sounds and waterways.

Groundfish occur in mixed-species aggregations. In trawl gear, especially, fishermen catch many unwanted sizes and species, some of which are targeted by other fisheries. These interactions have led to very complex management regimes involving myriad minimum landing sizes, mesh sizes, area closures, bycatch caps, and other measures. Many vessels have found it necessary, as a result of depleted stocks, to switch targets and gear on a seasonal basis, sometimes moving to very distant fishing grounds and retaining fish that were previously discarded because of their low value.

Dogfish and skates are now a heavy component of the groundfish catch, although even dogfish are now overfished. Recent years have seen the proportion of these lower-valued species increase on Georges Bank as the abundance of traditional groundfish stocks—cod, haddock, and flounder—decreased markedly due to overfishing. The scarcity of traditionally desired species has led to very heavy fishing pressure on some other stocks, such as summer flounder and monkfish, as fishermen attempt to shore up declining catches. Unhappily, this has created the "domino" overfishing effect that's common with multispecies groundfish fisheries, and makes regulating catches difficult.

Management of groundfish is also complicated in that the United States and Canada share many stocks. Each country has different management regimes, but both share the ignominy of failing to prevent stock collapses. However, in recent years, both countries have tried to reduce

FLUKE ½ DAY
BIG MAR-S II
HALF-DAY

LEFT: This Freeport, Long Island, summer flounder boat is part of the Northeast groundfish fleet. *Edward J. Pastula, NOAA Fisheries.* **BOTTOM LEFT:** "Buyboats" transported fish, crab, and oyster up and down the Chesapeake in the first part of the 20th century. *William B. Folsom, NOAA Fisheries/Chesapeake Bay Maritime Museum, St. Michaels, MD.* **BOTTOM RIGHT:** Anglers embark on a half-day trip from Belmar, New Jersey, in pursuit of a favorite target: summer flounder. *Edward J. Pastula, NOAA Fisheries*

LEFT: Skates taken as trawl bycatch serve as bait for Pt. Judith, Rhode Island, lobster boats. *William B. Falsam, NOAA Fisheries.* **CENTER:** Less familiar to consumers than New England cod or haddock, ocean pout are also part of the groundfish harvest. © *Nance S. Trueworthy.* **RIGHT:** Some Gloucester boats are again targeting herring, for both food and the pearly scales that add sheen to cosmetics. © *Nance S. Truewarthy*

overfishing of groundfish, especially Georges Bank cod, haddock, and yellowtail flounder, by taking such measures as closing fishing areas, requiring larger mesh, limiting entry to fishing grounds, controlling total fishing effort, and setting quotas.

The groundfish industry has also been beset by other, sometimes very visible controversies: gear and docking rights, ethnic squabbles, control over fish markets, interport rivalries, groundfish imports, and, most recently, capture of harbor porpoise in gillnets. Some historic problems haven't really been of industry's making. For example, a 1773 petition shows Block Island fishermen begging for government assistance to build a harbor with access to offshore grounds because channels to nearshore cod fishing had silted up and weren't navigable.

Groundfish harvesters have tried a number of ways to adjust to the steep declines in fisheries stocks, including dramatic hikes in the price of fish sold. They've experimented with new fisheries, rotated or laid off crews, sought outside employment and had their wives go to work, and found ways to cut operational costs (sometimes, as when insurance has been dropped, with very unhappy outcomes). Although movement into alternative fisheries has been a successful strategy for some owners of small and medium-sized (30–75-foot) boats, the larger vessels common to Gloucester and New Bedford are often too specialized to shift easily into other fisheries. Even the most flexible vessels have rough going as they try to squeeze into fisheries dominated by families and fleets working there for generations. Moratoriums on new entrants have been implemented in almost every fishery, as more and more fisheries are overcapitalized and participants must battle ferociously for ever-decreasing shares of the profits.

Ports in the Northeast vary considerably in the level of their economic dependence on groundfish. Some ports, such as New Bedford and Gloucester, are heavily dependent on groundfish and have suffered greatly from the effects of overfishing. Other ports, such as Portland, are more diversified and have survived by spreading their fishing activity across other resources.

In general, though, the job outlook for fishermen in the Northeast is bleak. For example, many towns continue to lose their textile mills, shoe factories, and timber mills—industries that previously offered jobs for those with little advanced education or special training—to southern sites (or even other countries). Thus, jobs related to fishing or other seafaring businesses—marine engine repair, and piloting passenger or cargo vessels—are sought by many displaced fishermen. Where fishermen do move into other fields, their positions more often than not are at a minimum wage. Aquaculture, touted by well-meaning outsiders as an ideal new occupation for jobless fishermen, is a questionable alternative at present because it requires farming-type skills very different from the "hunting" styles of fishermen. And in actuality, fishing has traditionally offered income relatively high for the required formal educational level.

Skilled mechanics, such as this Seaford, Virginia, crewman, have more job options when the fishing is poor. *Edward J. Pastula, NOAA Fisheries*

A Maine dragger awaits scrapping as part of a government-sponsored buyback to reduce the groundfish fleet. © *Nance S. Trueworthy*

Not surprisingly, having chosen an occupation with high potential income, independence, and self-reliance, fishermen have trusted more to their own and family resources than to public assistance or other social programs. However, the mid-1990s saw an outpouring of federal and state tax dollars to remove the highest-performing groundfish vessels through buy-back programs. Federal and state programs have also sought to develop fisheries and products for underutilized species, to encourage aquaculture (summer flounder is currently under cultivation) and expand job opportunities through tourist attractions in port towns. Although some of these programs have met with modest success, it is still too early to determine whether the millions in public funds will be able to revitalize fishing communities.

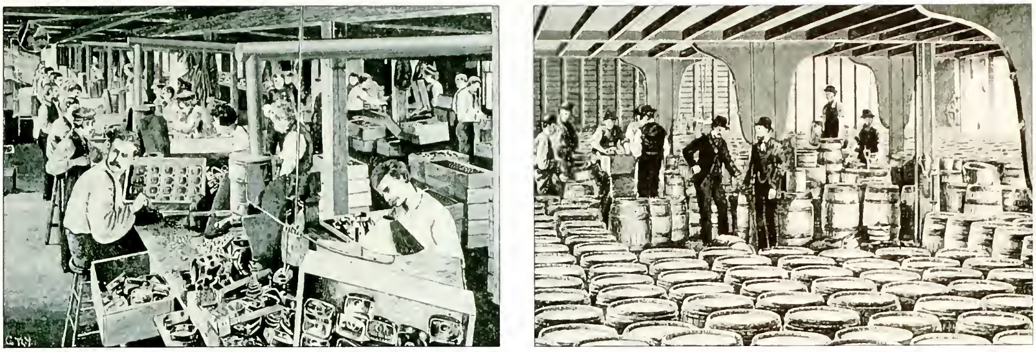
The Pelagics

"Pelagics" is the name given to resources that generally occur in large offshore schools near the surface or at mid-water levels. Northeast pelagics include Atlantic herring, Atlantic mackerel, butterfish, bluefish, and short- and long-finned squid. The resources are taken in a variety of gear: bottom trawls, mid-water trawls, gillnets, seines, and at one time, fixed weirs (used to catch herring along the Maine coast). These species bring fishermen more than $50 million a year, most of it from squid (discussed under "Other Molluscs"). The fisheries are seasonal, reflecting the stocks' migratory patterns, with large summer and fall spawning concentrations in the Gulf of Maine and on Georges Bank.

Historically, pelagics' monetary value has been low compared to groundfish, but two species—herring and mackerel—were a mainstay in colonial New England, just as they had been in Europe. Poor immigrants in the 19th and early 20th centuries also coveted these resources, turning them into pickled and rollmop herring and baked mackerel. But the fish have a high oil content and soft flesh, and were difficult to keep fresh for more than a few days, limiting their marketability.

Early colonists took mackerel in beach seines but began to use longlines by the end of the 19th century and purse seines by the mid-20th century. Gloucester and Provincetown, Massachusetts, were centers of the mackerel fishery, while the early herring trade was plied from Boston, Philadelphia, and New York, and later from Eastport (Maine) and Gloucester. By the 1880s, herring taken in traps and gillnets (and later, in purse seines) replaced mackerel in Maine's thriving canning industry for the smaller fish, and meal and oil processes for larger herring. Greater quantities of herring were

Once seriously overfished, the rebuilt Atlantic herring resource today offers new opportunities to fishermen. *Nance S. Trueworthy, NOAA Fisheries*



LEFT: Nineteenth-century sardine canning was labor-intensive and gave welcome employment to Maine families. **RIGHT:** A 19th-century Portland, Maine, packing plant holds casks of mackerel curing in salt. *From photographs by T.W. Smillie, The Fisheries and Fishery Industries of the United States. NOAA Fisheries*

shipped by railroad to the Midwest to feed the growing immigrant populations. Prior to the 1976 Magnuson Act, which effectively closed American waters to all foreign nations, mackerel and herring were exploited heavily by those fleets. The stocks declined severely, but in recent years, low harvest rates and improved recruitment have restored their numbers, although most use today is as bait fish.

Most of the pelagic finfish—mackerel, herring, and butterfish—are now underutilized, although bluefish is overfished. Mackerel and butterfish are managed under federal plans; herring is managed under an Atlantic States Marine Fisheries Commission plan; and bluefish is managed by both the Commission and the federal government. In recent years, European fleets have shown a renewed interest in exploiting herring and mackerel stocks, and the future may see joint fishing ventures with American firms. There are reservations, though: the domestic fishing industry fears that allowing very large trawlers may lead to a repeat of the groundfish debacle or a reprise of the earlier herring demise.

Butterfish—a small, silvery, deep-body species found off the Northeast and Mid-Atlantic and its cousin, the Gulf butterfish—are primarily exported to Japan, although Asian immigrants to this country have increased butterfish consumption here at home. The Gulf butterfish industry is quite new, resulting from cooperative U.S.–Japanese exploratory surveys in the mid-1980s that were searching primarily for squid, but found instead impressive

LEFT: When the bluefish are running, east coast piers like this one on Chesapeake Bay are crowded with eager anglers. © *William B. Folsom Photography, Inc.*
INSET: Bluefish share a spit with skinned rabbits for a traditional Chesapeake Bay Native American feast. © *William B. Folsom Photography, Inc.*
RIGHT: A crewman prepares to unload Atlantic butterfish destined for Japan, where the fish are highly esteemed. *Courtesy of Gene Cope, NOAA Fisheries*

concentrations of butterfish. Although there are relatively few butterfish boats in the Northeast and the Gulf, they bring the industry about $6 million a year.

Bluefish is targeted by both commercial and recreational fishermen. Commercial landings peaked in 1980, but have declined dramatically since then, and the stock is considered overfished today. Some experts suggest that the fish became especially abundant only with the decline of another ferocious predator, striped bass. Understanding the interactions of these two species in the complicated ocean ecosystem may help to explain their noticeably cyclic occurrence.

The bluefish fishery is hardly new, though. There are detailed records going back hundreds of years in Nantucket and Cape Cod, of alternating years of bluefish abundance and scarcity. Today, the species is especially sought by anglers in Chesapeake Bay and Tidewater Virginia, where the popular bluefish rodeos yield some of the largest specimens. Smaller bluefish are also taken in great numbers from piers and beaches, and many anglers claim these have a more delicate flavor than the larger fish. More than 80 percent of all bluefish today is taken by anglers. Among nearshore fish in the United States, this species has a reputation as a very bad actor: most veteran Mid- and South Atlantic fishermen—as well as unwary surf bathers in waters where the voracious fish are pursuing schools of menhaden—bear nasty scars from the slashing teeth of bluefish.

In the Southeast, the group of offshore-schooling fish called "coastal migratory pelagics" doesn't include herring, bluefish, butterfish, or squid. Instead, it consists of quite different mackerel- and tuna-like species. King and Spanish mackerel are the primary targets, together bringing commercial fishermen more than $7 million a year. The highly esteemed, exquisitely beautiful, and very abundant dolphin fish (also called dorado and mahi mahi), and the not-so-plentiful but equally tasty cobia and cero, round out the southern pelagics. All five species are far larger than the Atlantic mackerel, occur in much smaller schools or individually, and because of their grand fighting ability and superb taste, are sought by large numbers of recreational fishermen from New York to Texas and the Caribbean. All the migratory pelagics are federally managed through quotas, creel and size limits, and, for some states, daily landing limits and/or trip limits.

If the mighty cod is a Northeast icon, and striped bass almost mythic in the Mid-Atlantic, the South Atlantic's splendid king mackerel and bluefish have the honor of inspiring a popular North Carolina cabaret act, *King Mackerel and the Blues Are Running.* "Kings" have been fished commercially since the 1880s, beginning in Chesapeake Bay and now centered in North Carolina, southern Florida, and Grande Isle, Louisiana. The fish have historically been

Dolphin fish, or mahi mahi, has become one of the most prized items at "white linen" restaurants. © *William B. Folsom Photography, Inc.*

LEFT: Miami anglers sort their catch of king and Spanish mackerel after a half day on a head boat. *William B. Folsom, NOAA Fisheries.* **CENTER:** Cobia (lemonfish) are a fine-tasting fish welcome to both commercial and recreational fishermen at St. John's River, Florida. © *Jeff Greenberg/Unicorn Stock Photos.* **RIGHT:** Pride-of-catch status goes to Puerto Rican dolphin fish for their beauty, fighting ability, and great eating. *William B. Folsom, NOAA Fisheries*

taken with gillnets, troll lines, handlines, purse seines, otter trawls, and pound nets. But it was the gillnet fishery in the 1970s and 1980s that is thought to have resulted in serious overfishing of both king and Spanish mackerel. Stringent state–federal management has since led to recovery of Atlantic kings, as well as to the current rebuilding of the Gulf stock. Anglers are usually allotted about half the total catch each year, and their expenditures in pursuit of this species are impressive.

The commercial fishery for Spanish mackerel began even earlier than for kings, off New York and New Jersey in the 1850s. Today, almost all commercial landings are in Florida. This species has long been eagerly sought by anglers, who account for almost 40 percent of the landings. Commonly found nearer shore than kings, Spanish mackerel was especially vulnerable to the type of surrounding gillnets known as "run-arounds," and by the 1980s this species was also seriously overfished. As with kings, though, the stocks are starting to rebound as a result of strong management measures.

A continuing management issue for mackerel is that in the Gulf, some portion of the resources—especially king mackerel—is shared with Mexico. In spite of a long history of cooperative research between the two countries, information on Mexican mackerel catches is sometimes poor. Without a good understanding of how much of the stock is taken by each side, there still exists a potential for overfishing the resource.

The status of cobia (lemonfish) and dolphin fish stocks is unknown, although the Gulf's cobia yields are thought to be much greater than the Atlantic's. Cobia is more solitary in its habits and more difficult to find. The location of cobia "honey holes" is guarded ferociously by fishermen who have found them. So fishing pressure isn't usually heavy, and most cobia fishing is recreational. Dolphin fish is considered by many southern charter boat captains as an important target species, one whose abundance they can often rely on to satisfy customers seeking a good fishing experience. There is a rapidly growing market demand for this species (called mahi mahi on an increasing number of menus where restaurants want to avoid the worried looks of diners fearing they may be ordering porpoise), but there is no indication that the Atlantic (or Pacific) stocks are currently jeopardized. In fact, the species has been successfully cultured in experimental Hawaiian operations, and may find an aquaculture niche if culture costs can be restrained.

Atlantic Highly Migratory Species

Every region of the country has its fisheries troubles, usually associated in some way with lost economic or recreational opportunities. Two fisheries in particular—Pacific salmon and Atlantic bluefin tuna—exasperate fishermen, managers, and conservationists to a degree entirely disproportionate to their monetary worth; clearly, their worth can't be measured in dollars alone.

Bluefin tuna, along with swordfish, billfish (marlin, sailfish, and spearfish), and some sharks, are surface and mid-depth carnivores usually found offshore. For management purposes, these fish are collectively termed Atlantic "highly migratory species" because of their extensive migrations around—and often across—the ocean. Their average annual commercial dockside value is about $60–$65 million, but this may well be equaled, or even exceeded, by the expenditures of recreational tuna and billfish fishermen.

Living THE DREAM

Operators of the nation's thousands of small charter boats—vessels that vary widely in capacity from two to twenty or more paying passengers—are often retired or semi-retired people with extensive sportfishing experience. Many other charter boat owners come from the partyboat and head boat industry, where large vessels carry many more customers. But some, like Ted D'Esposito, of Islamorada in the Florida Keys, bring to their work skills and experience gained in America's commercial fisheries. Ted and other lucky colleagues have found a way to parlay their love of boating and fishing into a paying proposition.

At one time or another, every crew member aboard a commercial fishing vessel has probably dreamed of owning his or her own boat—the great American dream of "being the boss." But as intense competition, moratoriums on new entrants into fisheries, and heavy operating costs have increasingly limited owner-operator opportunities in commercial fisheries, fishermen have had to look elsewhere to achieve their goal. Many with vision and entrepreneurial spirit have found the answer in the country's steady growth of recreational fishing. For many, such as Ted D'Esposito, this has meant relocating to sunnier climes where angling is a year-round activity . . . although this probably doesn't represent an enormous sacrifice. The transition may take weeks, or it may occur over several years, but it's generally smooth, as fishermen from formerly competing sectors peacefully settle their charter boats into adjacent berths and share a sunset toast to the good life.

Ted D'Esposito, Islamorada, Florida (William B. Folsom, FOAA Fisheries)

RESEARCH
N.M.F.S.
TAGGING PROGRAM
CROWN HEIGHTS DISTRIBUTORS

An Ocean City, Maryland, charter boat releases a bluefin tuna as part of a growing conservation ethic. © *Edward J. Pastula, Reflective Imagery, Ltd.*

Most highly migratory species are harvested over broad stretches of the ocean by both U.S. and foreign fishermen, requiring management of international as well as domestic fleets. The American fleets are managed under the Magnuson–Stevens Act and the International Atlantic Tunas Convention Act. Authorized by the Convention Act, the International Commission for the Conservation of Atlantic Tunas (known to tuna fishermen everywhere as ICCAT, or "eye-cat") recommends harvesting agreements that are often controversial. Unfortunately, the primary fishing nations sometimes either can't agree on fishing and conservation objectives, or don't abide by agreements once they're adopted. An additional problem is that not all fishing nations are ICCAT members, and therefore aren't bound by the management recommendations. The recent United Nations agreement on conserving straddling fish stocks and highly migratory species may help to resolve these problems.

A charter boat crewman cleans tuna and dolphin fish on a dock in Manteo, North Carolina. *Edward J. Pastula, NOAA Fisheries*

Tuna, the historic filler of innumerable lunch-box sandwiches and dinner casseroles, is now the master dish at "white tablecloth" restaurants. Some of the supply is from the U.S. fleet, although much of it is imported. The majority of commercial and recreational landings comes from four species (bigeye, albacore, yellowfin, and skipjack) that collectively bring U.S. Atlantic commercial fishermen more than $24 million a year. Unlike Pacific tuna catches, far fewer skipjack are harvested than any of the other large Atlantic tunas. There are other tuna species in the Atlantic, though, and occasionally substantial catches of blackfin tuna and the smaller tunas (bullet tuna, frigate tuna, and little tunny).

Bluefin tuna, a relatively small harvest, is by far the most highly valued of American species and the largest tuna species, growing to 700 pounds or more. The increasingly rare giants, or bulls, destined for the lucrative Japanese sushi market have brought $20,000 *apiece*, although smaller bluefin bring far less. An astonishing $83,500 is recorded for a single Atlantic bluefin auctioned at the Tokyo market. Most of the catch is sold fresh, with the finest product valued for the savory sushi and sashimi, and the less fatty product still commanding a respectable price as fresh steaks.

In the 1960s and early 1970s, bluefin tuna represented 45–80 percent of the American fleet's highly migratory species harvest. Today, it has dropped to less than 10 percent, reflecting declining stocks, catch restrictions, and increasing harvests of other species. The annual commercial dockside value of bluefin is about $17 million, but expenditures by anglers specifically targeting bluefin tuna are also great.

Bluefin is taken by a variety of gear. Because the resource is so severely overfished, and so few bluefin of any size are allowed each vessel, skirmishes between commercial and recreational fishermen for

With a single fish worth thousands of dollars in Japan, many U.S. bluefin tuna are shipped to Tokyo's Tskiji market. *Robert D. Nordstrom, NOAA Fisheries*

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LEFT: The giant bluefin tuna like this one at Bailey's Island, Maine, are among the most pirzed of saltwater game fish. © *Nance S. Trueworthy.* **ABOVE:** Airfreighting is crucial to Puerto Rican fisheries that send swordfish and other premium fish to the east coast. *Julio A. Serrano, NOAA Fisheries.* **TOP RIGHT:** A good yellowfin tuna catch brings repeat business to this charter boat operation in Ocean City, Maryland. © *Edward J. Pastula, Reflective Imagery, Ltd.* **BOTTOM RIGHT:** Albacore from around the world are unloaded from a freighter at a large tuna cannery in Mayagüez, Puerto Rico. *William B. Folsom, NOAA Fisheries*

a larger share of the bluefin pie are the order of the day. There is also serious infighting among the various commercial fleets. In addition, the environmental community has weighed in heavily on bluefin harvests.

Yellowfin, bigeye, and albacore tuna are also heavily in demand for steaks and smoked products. Since all these species occur in vast schools, purse seines are generally used, but some pole fishing for albacore is still practiced. Valuable recreational fisheries for yellowfin and bigeye tuna exist throughout the Atlantic, Caribbean, and Gulf of Mexico. None of the other commercially important tunas, except bigeye, are overfished, although the stocks all appear to be nearly fully utilized. The status of the other tunas and tuna-like species is unknown.

The history, harvest, and use of swordfish are quite distinct from those for tuna. The meaty-textured and flavorful swordfish steak has long graced the tables of America's restaurants, although until recently, it was seldom served at home. Swordfish brings more than $35 million a year to the commercial fishery, but because they are solitary animals that usually inhabit deep water, relatively few swordfish are taken by anglers. Following the decline in bluefin tuna catches, swordfish rose in the early 1980s to the larger share of the Atlantic highly migratory species harvest. However, as this species, too, became overfished, it has in turn lost first place to yellowfin tuna, which today comprises almost half the landings of highly migratory species. Off New England, harpooners have historically taken most swordfish, especially the large females basking at the surface in the spring.

The discovery in the 1970s of large male swordfish and small fish of both sexes actively feeding in deeper waters throughout the year led to a greatly expanded fishery. The majority of the American fleet now uses longlines, most stretching for 20–30 miles, with hundreds of baited hooks and attached chemical "light sticks." These glowing devices, developed to meet the needs of the military for a low-heat, nonflammable light source, are enormously successful in attracting swordfish, tuna, and marlin, perhaps because they help these predators see at depths where their vision isn't normally acute. It's theorized that light sticks may actually work by attracting forage species (squid, sardine, and herring), which in turn attract the carnivores.

Managing swordfish has been a horror for many years because the animals are taken everywhere in the Atlantic, including the Caribbean and Gulf of Mexico. The Gulf, in fact, saw an intense Japanese longline fishery until the late 1970s, when the Magnuson Act was invoked to prohibit foreign fishing. Since then, American fishermen have put increasing pressure on the resource, but much of the current overfishing is also attributed to foreign fleets and to a heavy mortality of juveniles.

Current patterns of foreign fishing and the reduced swordfish stocks continue to alarm many in the industry. During the writing of this book, for example, some of the country's best-known chefs joined a conservation coalition determined to

A commercial swordfish longliner prepares to depart San Juan, Puerto Rico, for a week-long Caribbean fishing trip. *William B. Folsom, NOAA Fisheries*

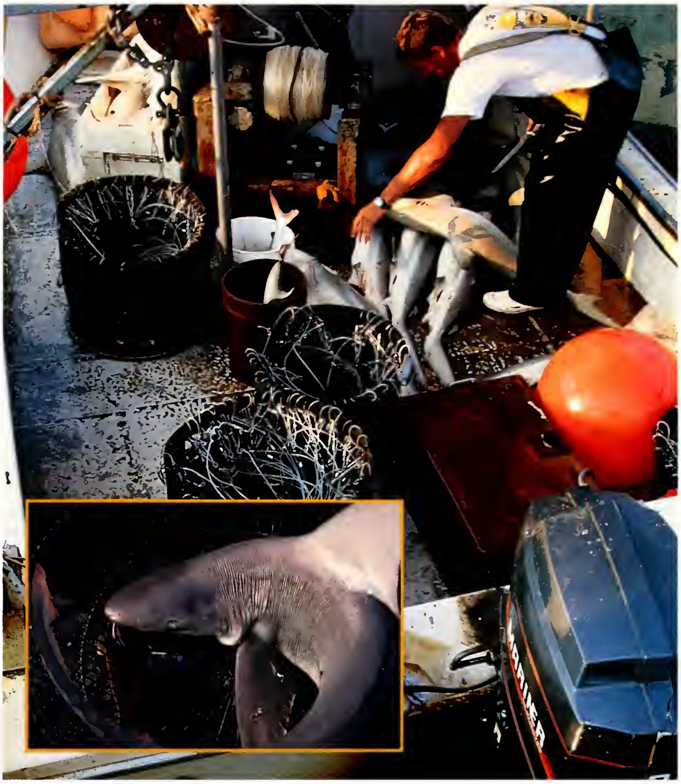
further decrease Atlantic swordfish quotas, pledging not to serve the species in their restaurants. An additional headache for U.S. swordfish fishermen is heavy importing from Spain and other swordfish-fishing nations. Many American boats that relocated to Puerto Rico for better access to good fishing grounds complain that the flood of cheap imports is forcing them to stop fishing—the dockside value of their catch barely covers their fuel costs, leaving little or no profit.

Atlantic billfish are fished and managed differently from swordfish because the four species (blue marlin, white marlin, sailfish, and longbill spearfish) are of value primarily to the recreational fishing industry. Gracing the walls of restaurants, tackle shops, and offices, billfish are generally prized more for their taxidermy and superb fighting ability than for their flesh. Blue marlin, in particular, grows to an enormous size—more than 1,000 pounds—and its spectacular leaps and fighting ability makes it the crown jewel of game fish. However, anglers who target billfish have long had a conservation ethic, and many of them participate in tag-and-release programs throughout the Atlantic to help scientists understand billfish migrations and distribution. Although taken as bycatch in dismaying numbers in both domestic and foreign swordfish and tuna longline fisheries, Atlantic billfish isn't generally sold in any quantity.

The status of billfish stocks is mixed. White marlin, blue marlin, and sailfish are

LEFT: An Islamorada, Florida, charter boat loaded with electronics also sports a flying bridge for spotting billfish. *William B. Folsom, NOAA Fisheries.* **RIGHT:** Rarely seen under water, a sailfish presents one of the Atlantic's most desired—and elusive—oceanic targets. © *William Boyce, William Boyce Photography*

CLASS ACTION
CAPT. DAVID P. MORRIS
Sportfishing
853-524



A South Carolina shark longliner prepares to unload the day's catch at his Folly Beach dock. *William B. Folsom, NOAA Fisheries.* **INSET:** Some Atlantic sharks formerly discarded as "trash fish" are now brought back for sale at good prices. *Commander Craig N. McLean, NOAA*

all overfished. Longbill spearfish are probably fully exploited. Because billfish captures are spread across so many ports and private docks, it's difficult to obtain complete estimates of the number caught each year. Fishing tournament surveys indicate a substantial increase in billfish fishing in the last 20 years, especially in the Southeast where, since 1972, tournaments have sometimes increased tenfold.

The last group of highly migratory species—sharks—poses management difficulties quite distinct from the other groups. Popularly regarded as fearsome predators, sharks have only recently become a highly valued food fish and game fish. And in almost record time for a fishery, some species have become overfished. In the 1970s, even the federal government began urging fishermen to exploit the largely untapped shark resources, and fresh shark meat began to appear in the dining room. But it was the growing Asian demand for sharkfin soup in the 1980s and better handling and marketing of shark meat that led to a much-expanded but unregulated shark fishery and an alarming decrease in some shark stocks.

There are more than 70 shark species in the nation's Atlantic, Gulf of Mexico, and Caribbean waters, with 39 of these managed under a federal plan that divides them into three groups. Several species—thresher, mako, porbeagle, blue, whitetip, sixgill, and sevengill—migrate long distances and are, therefore, known collectively as pelagic sharks. Another group, the 20 species collectively known as large coastal sharks, consists of species known to mariners as requiem sharks in honor of their grisly feeding habits. This group also includes other species: ragged-tooth, nurse, lemon, hammerhead, tiger, and the enormous (but not very tasty) whale shark and basking shark. The third management group, small coastal sharks, consists of six species: finetooth, blacknose, bonnethead, angel, and Caribbean and Atlantic sharpnose.

Still another small shark, the spiny dogfish, commonly associates with Northeast groundfish. The spiny dogfish, however, isn't loved by most fishermen: in addition to its far lower value, it's inclined to tear up nets by biting holes and plugging up the mesh so that undersized fish can't escape.

This fine-tasting, 800-pound shark was taken in Maine's cold coastal waters. © *Nance S. Trueworthy*

For many years, most sharks were considered unpalatable because the ammonia compounds in their blood tend to impart a sour flavor to the flesh. The solitary-living mackerel (mako) shark, however, has long been prized by anglers for their fine meat and fighting ability (although longliners ruefully acknowledge that there's probably nothing to match the line-tangling talent of a mako). Spiny dogfish has also captured a market share as the fresh or salted product of British fish-and-chips fame. In addition, there was a substantial market for shark liver oil in the first half of the century, but pharmaceutical synthesis of this health product after World War II significantly decreased demand for shark livers. There have also been profits to be made by shark-hide tanning. As long ago as 1919, a tannery was established near Morehead City, North Carolina, and processors soon found ways to use and market almost every part of the shark—liver oil, fresh meat, and, finally, rendering the remains into meal and fertilizer.

The large coastal sharks are eagerly sought by both anglers and longline fishermen. As a group, these species are considered overfished, and stringent conservation measures have been imposed. Pelagic sharks are also in demand by anglers, especially at Mid-Atlantic tournaments. They're commonly taken as bycatch on tuna and swordfish longlines, but their status is unknown. As for the small coastal sharks—a great many of which are taken as bycatch in the Gulf of Mexico shrimp fishery and discarded at sea—there is probably little room for any additional capture if the stocks are to remain healthy.

Sharks' peculiar life history makes them especially vulnerable to depletion. Unlike most fishes, sharks reproduce only after several years, have a long gestation period (more than two years in some species), and produce few young at a time—sometimes, only one or two pups. But it was the dismaying practice of "finning"—retaining the fins of some species but discarding the carcasses (often still alive)—that led conservationists and animal protectionists to demand a halt to the custom. It isn't difficult to see how a small boat unable to bring ashore a great many large carcasses could easily return with literally thousands of fins. Regulations now require that carcasses be landed as well as fins.

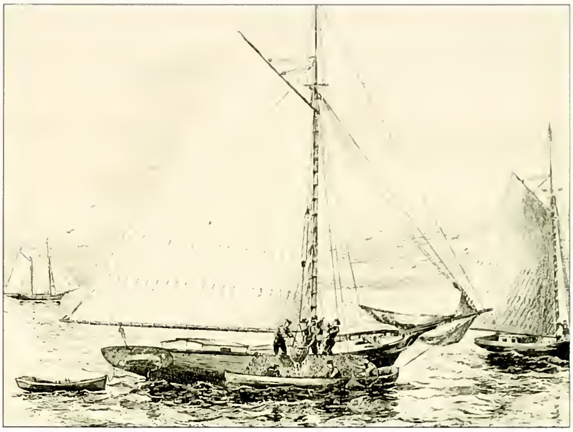
There is still considerable controversy about just how many sharks are really out there, in part because many of the sharks very closely resemble each other and are easily misidentified, even by experienced biologists. Some commercial shark fishermen also claim that obsolete data and poor estimates of the recreational catch have resulted in overly conservative management quotas. Considering that current quotas are as much as 50 percent lower than in previous years, fishermen's frustration is understandable.

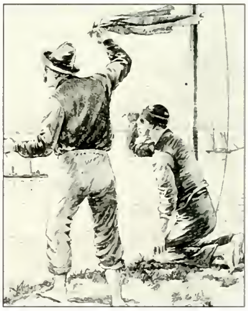
FISHING
DEEP SEA
BACK COUNTRY
BOAT RENTALS
BAIT - TACKLE

Menhaden

Until the recent exploitation of the enormous North Pacific groundfish resources, menhaden—the east coast's "mossbunkers" and the South's "pogies"—was the largest fishery by volume in the United States. The fishery is also one of America's oldest, beginning in southern New England and Long Island and expanding southward. The discovery of vast stocks of a second species in the Gulf of Mexico gave rise to the menhaden fishery there. Early colonists used the oily little herring-like fish mainly as crop

LEFT: A 15-foot fiberglass white shark attracts customers to an Islamorada, Florida, charter boat operation. *William B. Folsom, NOAA Fisheries.* **BELOW:** Rivaling swordfish in flavor and texture, the cartilaginous shark offers a bonus: no bones to watch for. © *William B. Folsom Photography, Inc.*





LEFT: The oily little menhaden is said to be the fertilizer whose use was taught to the pilgrims by Native Americans. © *Nance S. Truewarthy.* **ABOVE:** Nineteenth-century menhaden fishermen bail their catch into small "carry-away" sloops for transport to processors. *From a sketch by Captain B F. Conklin, The Fisheries and Fishery Industries of the United States, NOAA Fisheries.* **RIGHT:** Nineteenth-century menhaden boats relied on shore crews as lookouts for the shoaling "mossbunkers" or "pogies." *From a sketch by Captain B.F. Canklin, The Fisheries and Fishery Industries of the United States, NOAA Fisheries*

fertilizer, but by the mid-19th century, large quantities of salted menhaden were shipped south as cheap food for slaves. Later, factories from Maine to North Carolina processed menhaden into fish meal for chicken feed and into fish oil for tanning leather, making paint, and lighting lamps.

With the 1950s' collapse of the sardine stocks that sustained California's fish meal and fish oil industry, menhaden fishing increased along the Atlantic and Gulf Coasts. But now, the industry was assisted by aircraft spotters that could more easily locate the menhaden schooling 3 to 50 miles off the coast. Heavy fishing on the east coast took its seemingly inevitable toll on the Atlantic stock, although there are still large "pogy plants" in Reedville, Virginia, and Beaufort, North Carolina. The Gulf fishery now produces 60–70 percent of the total menhaden catch, with plants in Moss Point, Mississippi, and in Empire, Dulac, Morgan City, Intracoastal City, and Cameron, Louisiana. The primary products are still meal and oil, with some of the meal for mink feed and poultry chow, and some of the oil exported for production of margarine. Menhaden is also used in canned pet food and as bait for recreational fishing.

Purse seines have long been used to take menhaden. Early seines were deployed from dories carried to the offshore fishing grounds by sailing schooners and, later, by small steamers. Menhaden fishing generally occurs near shore, often just a few hundred yards off the beach. Today's menhaden boats are models of efficiency, with giant seines capable of hauling many tons. The catch brings more than $94 million a year to the vessels. Management is by

Menhaden plants, like this one in Moss Point, Mississippi, have long provided good jobs in coastal towns. *Lauri Lawson, NOAA Fisheries*

ZAPATA PROTEIN
MOSS POINT PLANT

individual states, coordinated through the Atlantic States and Gulf States Marine Fisheries Commissions.

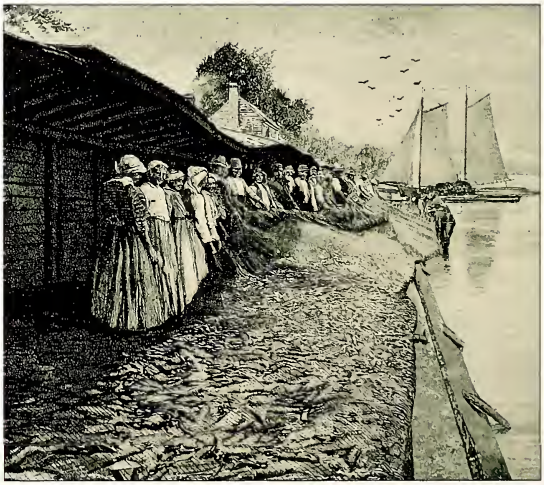
The industry is widely considered to be well managed, in part because the harvesting and processing operations have been made more efficient through consolidation of vessels and plants. The industry itself is noted for a strong leadership role in management. Nevertheless, some concerns remain that heavy fishing on smaller fish reduces the potential for greater weight production. Concerns have also been raised about bycatch, although studies show that both the Gulf and the Atlantic menhaden catches have very low percentages of bycatch of other finfish.

Anadromous Species

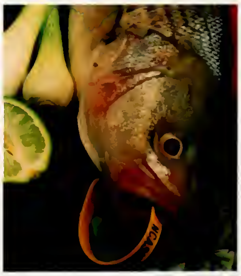
The Atlantic Coast is extraordinarily rich in anadromous fish—species that spawn in freshwater rivers and streams but spend most of their life in marine waters. Landings aren't generally large for most of these species. The river herrings (alewife, blueback herring, and hickory shad), American shad, and Atlantic sturgeon are managed under Atlantic States Marine Fisheries Commission plans, while the now rare shortnose sturgeon is regulated through a federal recovery plan prepared under the Endangered Species Act. Striped bass is also regulated primarily by the Commission under special Congressional authority because the species became so severely depleted. Atlantic salmon is federally regulated, but because the resource is shared by many North American and European nations, it's under the auspices of the international North Atlantic Salmon Conservation Organization. Another little-harvested resource, rainbow smelt, is managed by the states.

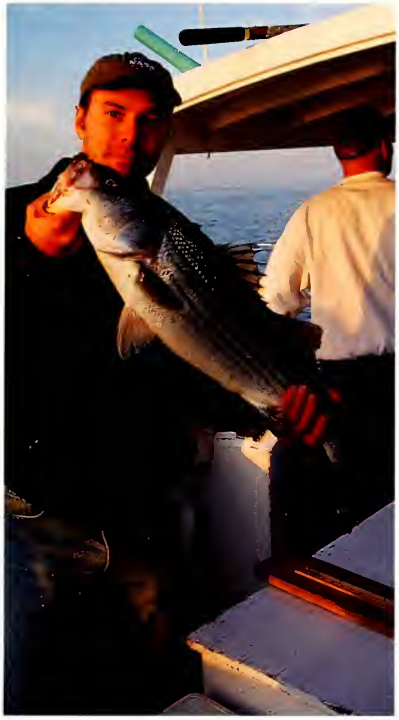
Atlantic salmon and striped bass are the best known—and most desired—of this group. Salmon was once the target for an extremely important fishery throughout New England, but overfishing by distant-water commercial gillnet fisheries off Canada and Greenland has badly depleted the U.S. resource, and commercial fishing has been prohibited for many years. The stock has also been harmed by dams that block returning fish from reaching the spawning grounds, by polluted streams, and by coastal development. The population today is so low that it has even been considered for listing under the Endangered Species Act.

Nevertheless, the potential for Atlantic salmon aquaculture in northern New England has long been considered. All the east coast salmon farm "pens" are in Maine, and some of the product is available today in seafood markets throughout the nation. The resource, though, meets stiff competition from imports of the same farmed species from Norway, Scotland, and Canada, and increasingly, Chile, as well as both pen-raised and wild Pacific salmon. Farming salmon is always a chancy operation. In addition to market vagaries, penned salmon are vulnerable to climatic fluctuations and some devastating pathogens, including the horrendous hemorrhagic disease that has ravished both Norwegian and Northwest salmon farms (to date, the disease seems not to have struck Atlantic salmon farms). The pens



LEFT: Most Atlantic salmon found today in American markets come from either foreign or domestic fish farms. © *William B. Folsom Photography, Inc.* **ABOVE:** Residents of 19-century Albemarle Sound, North Carolina, haul alewives during the species' annual spawning run. *From a photograph (photographer unknown), The Fisheries and Fishery Industries of the United States, NOAA Fisheries.* **RIGHT:** A striped bass bought in Virginia displays the tag indicating it was legally caught in North Carolina. © *William B. Folsom Photography, Inc.*





Chesapeake striped bass are fully recovered, to the joy of these anglers near Norfolk, Virginia. © *William B. Folsom Photography, Inc.*

are also vulnerable to predation by rapacious seals that tear the net enclosures in search of an easy meal, which creates a quandary about how to deal with animals protected under the Marine Mammal Protection Act.

Like wild Atlantic salmon stocks, striped bass (also called rockfish) has suffered the ravages of overfishing. Unlike salmon, however, highly restrictive management actions over many years have resulted in a spectacularly strong comeback for stripers. Their presence nearshore, their much admired fighting ability, and their fine taste make them the fish of choice for a vast navy of anglers whose small boats can't go far offshore. Stripers occur along the Atlantic Coast from Maine to North Carolina and the northern Gulf of Mexico, and are especially abundant in the Chesapeake and Delaware Bays. They were also successfully introduced on the west coast in the late 19th century. Most Atlantic stocks are now considered fully restored, and carefully monitored commercial and recreational fishing activities are again allowed.

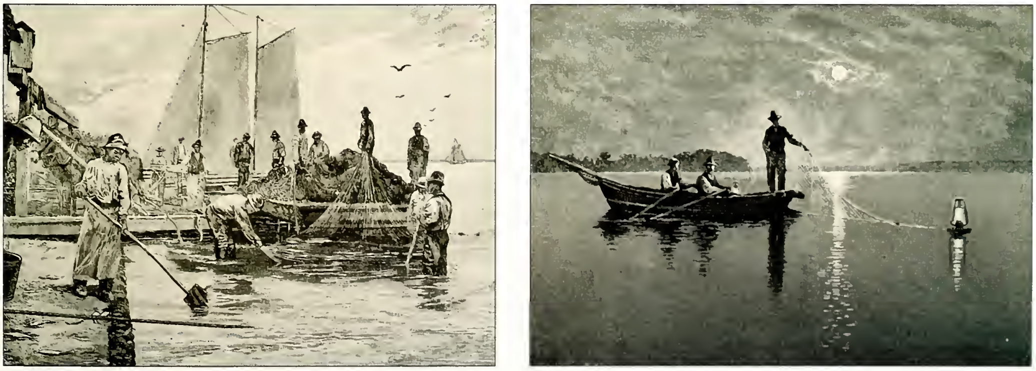
The commercial fishery for striped bass uses haul seines, trawls, pound nets, gillnets, and hook-and-line, but its landings are small compared to recreational catches. Much of the resource available in fish markets is actually not wild, but is a cultured, hybrid cross of striped bass and a freshwater species, white bass. In the Gulf of Mexico, careful husbandry has meant the return of striped bass to coastal rivers and streams, and some of the fish are truly immense. The fishery there is recreational only, and likely to remain so.

Such herring-like fishes as alewife, blueback, and shad are the only other anadromous resources taken in any quantity today, and even landings of these species are a fraction of historical catches. Alewife, especially, was at one time an important species in the Mid-Atlantic, taken in shoreline pound nets and by small purse seines for reduction to meal and oil. A surprising number of them were also taken by handheld scoops during their spawning runs into creeks and streams, but catches today are quite small.

In precolonial times, Native Americans used crude nets made of bushes and reeds to take American and hickory shad along the Atlantic Coast. The fish were so abundant even in the late 19th century that the Virginia Commission of Fisheries reported that children could easily spear them in shoal water. Unfortunately, the important shad fisheries of Virginia and Maryland succumbed to heavy fishing pressure, the construction of dams that blocked their spawning rivers, and habitat degradation, and the stocks have never recovered to their former levels of abundance. Shad is still valued for the roe as well as for the flesh served up as planked whole fish in Mid-Atlantic festivals. "Planking" is a Native American method of imparting a savory smoky flavor to this otherwise bony but succulent fish by cooking it on cedar, hickory, or other aromatic wooden boards.

Another freshwater–saltwater resource, American eel, is also undergoing heavy fishing pressure. The species is not really anadromous, but "catadromous," spawning far out in the Atlantic's Sargasso Sea, with

LEFT: Mule-drawn haul seines were used to take alewife and herring in the 19th century. **RIGHT:** Gillnets were set at night when Chesapeake Bay shad returned annually to the Susquehanna River. *From photographs (photographer unknown),* The Fisheries and Fishery Industries of the United States, *NOAA Fisheries*



Harvesting the glasslike elvers is restricted in North Carolina, so fishermen take the adults with eel pots. *Courtesy of Gene Cope, NOAA Fisheries*

some juveniles migrating into American streams to mature and others into European rivers. From the pre-Columbian era up until the 20th century, eel was taken in weirs from New York to North Carolina as they migrated back out to sea to spawn. Most are shipped alive, although some gutted and frozen product is also sold. The species is jeopardized by the growing demand for elvers, the three-inch transparent larvae (also called "glass eels" and "spaghetti eels") treasured as a great delicacy by Asians and for traditional Basque dishes. Some coastal states, such as Massachusetts and New Jersey, have prohibited the harvest of these very young eels in an effort to protect the stock. The problem may be solved by the burgeoning eel aquaculture industry, which has begun to supply the strong domestic market for eel, but has its eye on more profitable sales to Belgium, France, Italy, and Japan.

The prehistoric-looking anadromous sturgeon was also a favored dish early in the nation's history, and is still considered choice by those who have been lucky enough to sample it. Called "Albany beef" because of its meaty texture and former abundance, this behemoth was originally taken by spear and, later, by gillnets and trammel nets. Today, only the white sturgeon is taken in Atlantic marine waters and, because the resource is so scarce, in only very small numbers off South Carolina and Georgia. Taking other American sturgeon species is prohibited, and some are listed as endangered species.

Reef Fish

More than 100 tropical and subtropical species in the Gulf of Mexico, South Atlantic, and Caribbean are lumped together as "reef fish." The grouping is both for management purposes and because these fish generally prefer coral reefs, artificial structures, or other hard-bottom areas. Many are snapper and grouper, which bring commercial fishermen up to $40 million a year, but the group also includes porgy, jack, amberjack, grunt, sea bass, wreckfish, parrotfish, and tilefish. On offshore Gulf of Mexico banks, such as the Flower Garden Banks off Texas and deepwater reefs off Louisiana and Florida, magnificent queen snapper, snowy and yellowedge grouper, and other very large reef species are a strong draw for charter boat customers. Shallower reefs also attract glass-bottom boats and recreational diving fleets, and it's not hard to imagine these businesses' concern about overfishing or other activities that might decrease fish populations.

Many fishermen have primarily targeted snappers, especially red snapper. This is still the choicest reef species overall and is the subject of great current controversy because of its prevalence in the bycatch of shrimp trawl nets. The commercial snapper fishery was pioneered in about 1850 by fishermen from New England, who customarily shifted operations to Gulf waters during the winter. The first snapper boats fished from northwestern Florida west to Mobile Bay, Alabama, but in the 1880s, the fishery expanded as far south as Florida's Dry Tortugas and, shortly after, west to Louisiana and Texas.

By 1900, the snapper fleet operated mostly out of Key West, with large schooners known as "smacks," smaller schooners and sloops called "chings," and little single-mast sailboats, or "smackees." Fishermen relied on muscle-powered haul seines, handlines, and gillnets, and although their main target was red snapper, they sold just about everything they caught. Early boats had built-in wells that could keep a moderate number of fish alive long enough to land them in good condition. The development of ice-manufacturing plants in the late 1890s made it possible to store larger catches on longer trips. In the Caribbean, traditional Puerto Rican fisheries used rowboats or small sailing craft to set fishpots (*nasas*) made of mangrove framing covered with chicken wire and set along reef areas to catch both reef fish and spiny lobster.

Healthy reef fish stocks are vital to the Florida sport diving industry. *© William Boyce Photography*

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TOP LEFT: A crew member divides the day's yellowtail snapper catch taken on an Islamorada, Florida, partyboat. **BOTTOM LEFT:** Local inhabitants of Rincon, on the west coast of Puerto Rico, admire a good catch of red snapper. **RIGHT:** Colorful dories line the beach at Crashboat, Puerto Rico, after a day pursuing snapper, mackerel, and dolphin fish. *Photos by William B. Folsom, NOAA Fisheries*

Today, reef fish are taken by a great variety of gear. The commercial fishery generally uses fish traps, longlines, hook-and-line, spears, trammel nets, and barrier nets. Large steel-hulled boats with power blocks and huge drums of longlines work the deepwater reefs offshore, with smaller boats or even dories using the specialized lines known as Kali poles and bandit rigs. From North Carolina southward along the coast, mid-sized boats deploy specialized traps for black sea bass and other smaller species. Gillnets and trammel nets are the gear of choice for the very small boats fishing in Caribbean bays and lagoons, and in some areas, fishermen use simple hook-and-line outfits carefully dragged across shallow reefs to snag groupers hiding in coral heads. Some types of reef fish gear are prohibited in certain areas. For example, fish traps, roller trawls, and "bang sticks"—the blasting powerheads used on spearguns—may not be used in some inshore stressed areas.

Unfortunately, the ease of capturing reef fish with just about any gear has led to localized overfishing and, for some species, widespread depletion. This is especially true in the U.S. Caribbean, where fishermen displaced from mainland fisheries often set much longer—and more efficient—nets than generations of local inhabitants have been accustomed to using. As a result, some stocks have nearly vanished, and it's not surprising in the Virgin Islands to find fishermen reduced to peddling an assortment of small but quite exotic parrotfish, butterfly fish, angelfish, squirrelfish, and triggerfish off the back of trucks. In Puerto Rico, some areas in the Mona Passage on the island's western edge still yield fine catches of magnificent red and vermillion snapper (as well as large dolphin fish and mackerel) and provide a good—if erratic—living to the local dory fleets.

In addition to red snapper, other Gulf of Mexico reef fish considered to be overfished are Nassau grouper and jewfish. But because the status of most Gulf reef fish is unknown, others may be in trouble. In the Atlantic states, red and vermillion snapper are overfished, as are red porgy and 18 species of grouper. But again, the status of many other species, including sea bass and amberjack, is unknown. In the Caribbean, there isn't much information on the status of any reef species except Nassau grouper and jewfish, which are overfished. Heavy demand by both commercial and recreational

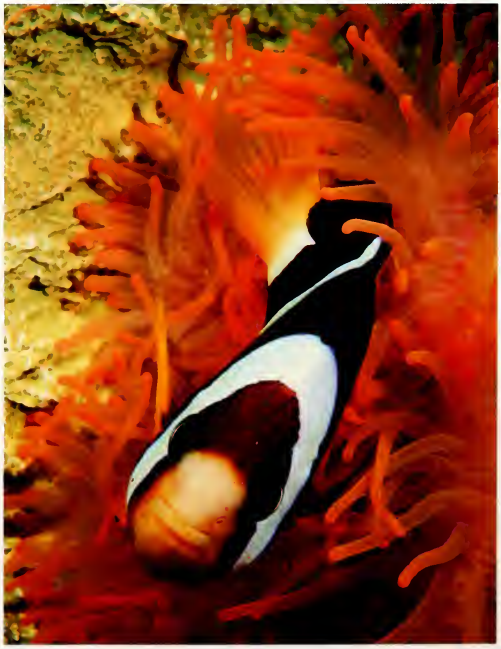
JIM'S PIER
65 SOUTH PADRE ISLAND

LEFT: Small snapper, grouper, and parrotfish are sold from the back of a truck in St. Thomas, Virgin Islands. *William B. Folsom, NOAA Fisheries.* **CENTER:** Filleted grouper carcasses attest to the reef fish bounty harvested by this Tarpon Springs, Florida, head boat. *William B. Folsom, NOAA Fisheries.* **RIGHT:** Deepwater snapper off Texas offer exciting recreational fishing to both charter and private boats. © *Index Stock/Richard Stockton*

fishermen and the consistently high market price make reef fish especially vulnerable to overfishing. Many reef species are particularly vulnerable to depletion owing to their slow growth, delayed maturation, and the ease with which they're captured, and their effective management can be difficult because of considerable confusion about the identity of species and because the status of many species is unknown.

Management is distinctly different for one reef species in the South Atlantic—wreckfish, named for the juveniles' association with floating wreckage or other flotsam. This species grows quite large but is taken only in a tiny area off Georgia and North Florida, and by only 40 or so vessels. The fish is managed under an individual transferable quota (ITQ) system that gives participants a quota that can be taken any time during the season or can be bartered or sold to another fisherman; no recreational take is allowed. Managers and some snapper fishermen have hoped that the success of this ITQ program would inspire similar management regimes for other species, especially Gulf of Mexico red snapper, but such "privatization" has met considerable local resistance.

There is currently very limited reef fish aquaculture, although the technology for farm pond culture has been developed. Raising the fish is costly and labor intensive, but it seems likely that red snapper, in particular, may soon come under culture. However, sophisticated facilities in Puerto Rico and Florida are producing many species of captive-bred clownfish, the colorful little anemone-dwellers so highly valued in the saltwater aquarium trade. Production of other small ornamental species from the Atlantic and Pacific—gobies, gorgonian corals, hard corals, small jellyfish, and tridacna clams—is also underway.



NEAR RIGHT: Red snapper are sought by commercial and recreational fishermen alike, and worth every penny of their hefty market price. © *William B. Folsom Photography, Inc.* **FAR RIGHT:** Demand for clown anemone fish and other colorful tropicals has fueled the growing aquarium aquaculture industry. © *Tim G. Simos, Clear-Water Images*

Another issue concerns the proliferation of artificial reefs, especially in the Gulf of Mexico. Snapper, grouper, and many other predators are unquestionably attracted to the constructions as good feeding grounds. Recreational fishermen, especially, claim that the submerged oil platforms, concrete bunkers, trolley cars, piles of automobile tires, and other structures increase reef fish populations and, therefore, fishing opportunities. The scientific evidence to date suggests that artificial reefs may have just the opposite effect: by congregating the fish in the area and providing fishermen greater accessibility to them, the structures actually increase the amount of fishing and the catch rates, and thus increase the probability of overexploitation. The argument will, no doubt, continue to rage, but meanwhile, the Atlantic and Gulf Coasts have seen the development of a great many artificial reefs that provide good fishing for thousands of anglers.

Seatrout fishermen in Louisiana's flood-prone Grande Island solve their housing needs imaginatively. *Lauri Lawson, NOAA Fisheries*

Croaker and Drum

Although often inhabiting sandy and muddy bottoms of coastal areas, most croaker and drum aren't really considered "groundfish" or "bottomfish" in that many of them don't occur as part of large mixed-species assemblages like those in the Northeast. There are exceptions, of course. Spot, kingfish (also called "whiting," but distinct from the real, cod-like whiting of the Northeast), and Atlantic croaker are often taken as bycatch in shrimp trawl, in both the Gulf of Mexico and the South Atlantic and sometimes in very large quantities. Most of this bycatch is dead and destined for at-sea discarding, but some, especially croaker, is retained for use in canned pet food or is frozen to feed mink on fur farms. Commercial landings of croaker currently bring fishermen about $7 million a year.

The croaker-like seatrout, though, is highly valued as both a food- and a game fish, although landings bring commercial fishermen only about $6 million a year. The three seatrout species, especially spotted seatrout, lure anglers by the thousands to such famous hot spots as Cocodrie, south of New Orleans; Swan Quarter, in North Carolina; and along the Texas coast, where spotted seatrout has been designated as strictly a game fish. Unfortunately, heavy fishing pressure has reduced the abundance of spotted seatrout, and it's currently considered overfished. Florida landings of the species have especially declined from the 1960s, partly as a result of heavy exploitation, but also as a result of habitat destruction from coastal development. Rebuilding this resource is likely under new minimum-size regulations and a sharp reduction in the commercial fishery. As with almost all fishery management regimes, there is a cost: the recently implemented statewide ban on the nets used to take seatrout in Florida may well put some small commercial fishing operations out of business (only the relatively inefficient hook-and-line and cast nets are now allowed).

A few trawlers deliver croaker and other groundfish to a Pascagoula, Mississippi, pet food cannery. *William B. Folsom, NOAA Fisheries*

LEFT: A resident of Tybee Island, South Carolina, targets the small but fine-tasting spot, ubiquitous along Atlantic shores. *William B. Folsom, NOAA Fisheries.* **CENTER:** The Gulf of Mexico's famed red drum attracts anglers of all ages, such as this happy Florida group. © *Index Stock/Jeff Greenberg.* **RIGHT:** A red drum angler working the shallows off Padre Island, Texas, lets his shirt announce his target. *William B. Folsom, NOAA Fisheries*

Other drum-like species also have their following. In the fall, hordes of anglers descend on South Atlantic beaches and piers during spawning runs of the humble spot when its golden belly advertises the fine buttery quality of its flesh. Fresh spot and Atlantic croaker are both commonly found in seafood markets, but at lower prices than the more highly valued seatrout.

And, of course, there's Louisiana's famous "blackened redfish" (red drum), now notorious for its rapid stock slide into near-oblivion following the craze set off by New Orleans' noted Cajun chef Paul Prudhomme in the early 1980s. Commercial takes of this once-overfished species are still generally prohibited, in part because of strong opposition by recreational fishermen. Some restaurants feature a close substitute—the still very abundant black drum.

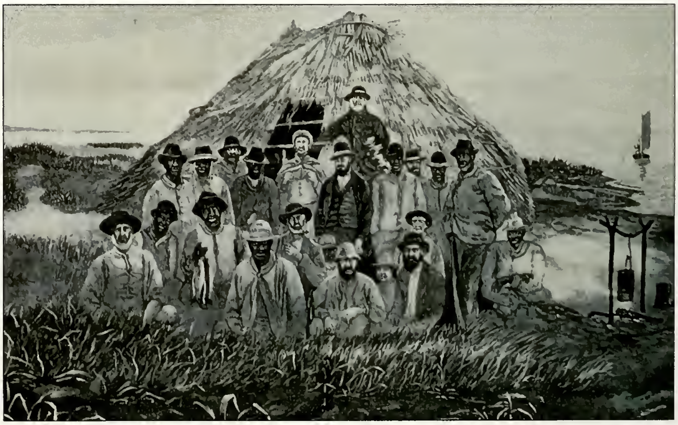
Red drum is an immensely popular recreational fish, and currently enjoys most of the allocation for the resource. Southern anglers pursue the species in nearshore waters everywhere—the younger "puppy drum" or "channel bass" can be taken by small boats, from fishing piers, or even from the beach. But the species is also intensively cultured in Texas ponds and is stocked in several of the state's vast bay systems that attract hordes of anglers intent on a large catch of redfish.

Other Finfish

Seafood market displays often boast an impressive variety of other Atlantic species, but many of these are largely taken as bycatch in other fisheries or by very small inshore operations. Some are quite good eating, though: sea squab, a domestic relative of Japan's delicate—but sometimes deadly—*fugu* (pufferfish); tautog; sheepshead; tilefish; and white perch. And some have found a following in coastal fishing communities, where they draw dedicated—if small—crowds to such celebrations as Narragansett's feasts of fried smelt and broiled eel. The elongated, silvery cutlassfish is a fine-tasting species that has found a place in the Gulf of Mexico's Vietnamese cuisine. And when the sporadic tilefish shows up in spotty concentrations, it's eagerly harvested by line fishermen ordinarily targeting the deeper-water species.

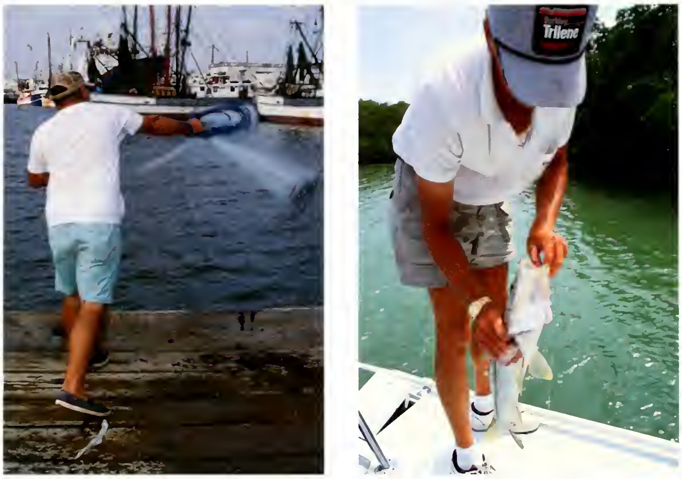
Most of these nearshore resources aren't particularly abundant. However, one species—mullet—was taken in great quantities by netters in small boats until the recent Florida net ban. Used mostly for the roe, which is highly valued in Asia, mullet flesh is also locally prized as a fresh and smoked product. However, the net ban, intended to reduce finfish bycatch, has reduced the mullet fishery to boats from

Nineteenth-century mullet fishermen pose in front of a makeshift hut at their North Carolina fish camp. *From a photograph (photographer unknown), The Fisheries and Fishery Industries of the United States, NOAA Fisheries*



Alabama and the South Atlantic states, with a small amount of young Florida mullet taken by snagging or with cast nets, primarily for bait. Mullet currently brings fishermen only about $12 million a year, but in the early part of the 20th century, mullet replaced oysters as the most valuable Gulf fishery, and even in the 1960s, was considered an underutilized resource.

The net ban, especially, illustrates the influence of recreational fishing organizations in many states on allocations between commercial and recreational users. In some cases, nearshore species have essentially become game fish because they're not very desirable as food fish. Thus, the famed tarpon, bonefish, and ladyfish, whose flesh is studded with tiny bones, attract thousands of anglers to shallow Florida bays and brackish streams for the thrill of the chase. Most hooked fish are returned to the sea alive as part of a growing angler ethic to reduce mortality of these species. Some other species that provide very fine eating, like pompano and snook, have been declared game fish to support the extraordinarily valuable Florida recreational fishing industry.



LEFT: This fisherman in Aransas Pass, Texas, like many anglers, is adept at cast-netting for bait fish. *William B. Folsom, NOAA Fisheries.* **RIGHT:** Florida's snook, available only to recreational fishermen, is considered one the world's finest food fishes. © *William B. Folsom Photography, Inc.*

Still other resources, such as Florida's Spanish sardine, are harvested commercially, but primarily as bait for recreational fishing. There have been proposals for an expanded sardine fishery for meal and other commercial products, but these usually generate alarm among anglers concerned that the sardines must be reserved as forage for the large carnivorous game species.

The thrill of a lifetime—going a few rounds with one of Florida's magnificent fighting tarpon. © *Index Stock/Edward Slater*

Mention must also be made of the growing fishery for the strange-looking hagfish, an habitué of the deep, colder waters of the Atlantic (and Pacific). This very primitive, jawless vertebrate is sought as the source of "eelskin," and when tanned (usually in Korea), the supple, elegant skins are pieced together for handsome wallets, purses, and other leather goods. The creatures are also very appropriately known as "slime-eels" for the copious mass of mucous they ooze into the traps used to catch them. But so little is known of their abundance and distribution, some scientists fear that this currently unmanaged resource may be rapidly overfished.

Shrimp

Most of the shrimp Americans eat aren't trawled up by picturesque Cajun shrimp boats, but are raised in extensive Latin American and Asian farm ponds. Although U.S. per capita shrimp consumption has greatly increased in recent decades, much of this comes from aquaculture. But quite a few wild Atlantic shrimp are still landed—three "penaeid" species from the warm southeastern waters, and smaller coldwater shrimp from New England.

Even with the recent explosive growth of North Pacific groundfish harvests, shrimp remains the nation's single most valuable fishery resource. Because of shrimp, many Gulf of Mexico towns top the list of important U.S. fisheries ports in terms of value: Empire–Venice and Dulac–Chauvin, in Louisiana; and Galveston, Port Arthur, Palacios, and Aransas Pass–Rockport in Texas. But shrimp are also landed in literally hundreds of other Southeast communities from North Carolina to the Mexican border. Shrimp bring Gulf fishermen alone more than $400 million a year, another $60–$90 million to South Atlantic states, and $15 million to New England. It's hardly surprising that the Southeast is alive during the shrimping season with lively, colorful festivals and family-oriented blessings of the fleet.

Gulf of Mexico shrimping initially was a daytime operation confined to bays and river mouths, and only one species—white

FAR LEFT: The annual Fernandina Beach, Florida, Shrimp Fest draws eager crowds to the city's docks. © *Index Stock/Wendell Metzen.* **ABOVE:** A small Texas shrimp boat heads out of Corpus Christi for a day-long fishing trip in the productive Laguna Madre. *William B. Folsom, NOAA Fisheries.* **NEAR LEFT:** This gourmet market in metropolitan Washington, D.C., offers up a mouth-watering platter of shrimp. *William B. Folsom, NOAA Fisheries*

shrimp—was taken. A small beach seining industry began in early 19th-century Louisiana to supply the nation's growing Chinese population with sun-dried shrimp. South Atlantic seining for shrimp began soon afterward, in the mid-1860s, with the introduction of canning. But the American shrimp industry didn't get off the ground until after freezing techniques were perfected in the 1920s, along with the diesel-powered trawl introduced in 1912, and the invention of automatic shrimp-peeling machines. The burgeoning industry attracted an eager and heavily immigrant labor force, and their thousands of descendants have become the fascinating mix of people working the industry today.

The great burst of shrimp fishing began in 1936 with the discovery of immense stocks of white shrimp off Louisiana. In

LEFT: Small wingnetters, like this one in Louisiana's Bayou La Fourche, take a surprising amount of the smaller-sized shrimp. *Lauri Lawson, NOAA Fisheries.*
RIGHT: Mississippi shrimp boats, like these in Biloxi, are often identical to those of Louisiana and Texas. *William B. Folsom, NOAA Fisheries*

1947 an even larger population of nocturnally active brown shrimp were found in the deeper waters off Texas, Louisiana, Alabama, and Mississippi. Scarcely two years later, a third species, pink shrimp (also nocturnal) was found in concentrations off the Florida Keys. All three species are intensively fished today. A few Southeast fishermen specialize in other shrimp—royal red, seabob, and rock shrimp—but these species don't generally occur in amounts that can support large fisheries. However, two additional species of large penaeids—Pacific black tiger and Pacific white—have been imported for aquaculture ponds in the United States.

Most commercial shrimping today is done with trawls. The gear comes in a seemingly endless variety, modified and transformed over the decades for different bottom configurations and target species and other factors. Small boats take inshore day trips, and larger ones ply the waters far offshore Texas and Louisiana on trips of up to two weeks. Most trawls are outfitted with turtle excluder devices (TEDs) that permit the escape of endangered sea turtle drawn into the net. Increasingly, shrimp nets also contain bycatch reduction devices (BRDs) to reduce the unintended capture of finfish.

Trawling is by no means the only commercial method for harvesting shrimp. In Georgia, special cast nets take a share of this largely inshore resource. The picturesque bayous and bays of Louisiana and Texas abound with wingnetters and butterfly netters, the little anchored boats and platforms that lower their square-framed netting panels to catch shrimp migrating out to sea. And although not much in use today except for scientific sampling, marshland weirs permit the passive capture of small migrating shrimp.

A considerable amount of "recreational" shrimping also goes on, for both food and bait shrimp. Most bait shrimp sold in the South is taken by trawlers working inshore bays and waterways. Anglers and subsistence fishermen also often use cast nets to take shrimp, and a surprising number of fishermen—both commercial and recreational—tow efficient little 16-foot otter trawls behind a skiff or other outboard. This catch is landed at thousands of private docks and beaches and is often sold from ice chests and truck tailgates along the roadside. This is sometimes a very considerable amount of shrimp, but these catches often go unrecorded, and currently there is no way to ascertain their impact on overall shrimp landings.

Both Gulf and Atlantic shrimp fisheries are managed through federal plans. However, the states have the stronger role in determining seasonal openings and closures, which are carefully timed to protect the shrimp stocks' overwintering inshore and to let them grow to a larger size before they move out to sea. Southeastern shrimp stocks aren't generally overfished, although they're harvested at probably maximum levels. Nevertheless, Southeast shrimpers face several problems in addition to a heavy volume of shrimp imports. In the Gulf, especially, there are simply too many vessels—individual profits are sometimes quite small, and many shrimpers go out of business each year. The up side of this fleet reduction is a sizable decrease in the finfish bycatch, which is probably shrimping's single biggest headache.

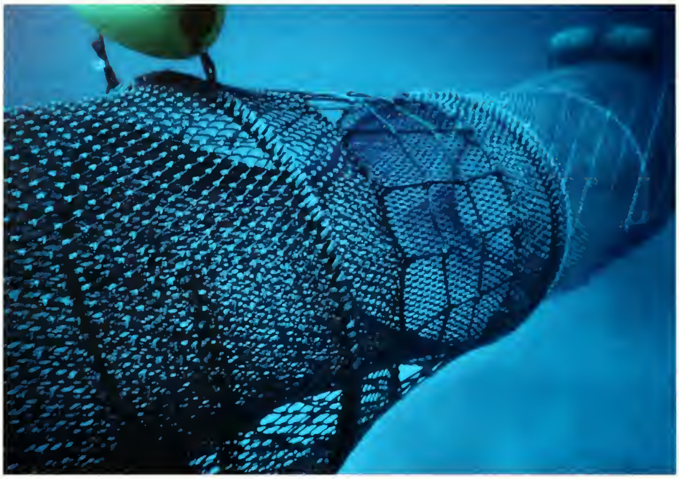
The issue of bycatch is serious. Shrimp fisheries use small-mesh nets that also catch fish, sea turtle, and many other creatures,

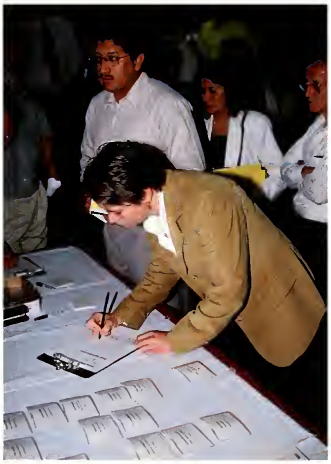
Shifting ROLES

For many years, June Krantz has been a successful lobster trapper in Casco Bay, Maine, and is only one of thousands of women participating in commercial American fisheries. Many, like June, own and operate small boats, setting their traps, nets, or lines exactly as their male counterparts do, and using the same selling and marketing methods. Other women, though, have moved from the small business framework into large-scale fishing operations: there are successful entrepreneurs from Maine to Hawaii who own very large vessels or even whole fleets. Many women also own or manage successful shore-based operations—processing plants, wholesale or retail markets, seafood brokerages, shipping companies, and even charter boats and partyboats—either by themselves or as part of family enterprises.

In fact, the growth and success of the nation's fisheries have always depended heavily on the energy and resourcefulness of its women. For generations, fishermen have relied on their wives' and daughters' shrewd business sense and initiative to balance the books, develop profitable markets, and secure venture capital for operations. And some ports seem always to have welcomed those vigorous women who preferred to set to sea themselves. In recent years, though, as women have moved into professions and occupations previously denied them, more and more women have chosen to leave supporting roles, emerging as dynamic entrepreneurs in commercial and recreational sectors, and as influential advocates for the American fishing industry.

June Krantz, Peaks Island, Maine (Nance S. Trueworthy, NOAA)





ABOVE: This shrimp net has both a mesh-panel, bycatch-reduction device (BRD) (left) and a grill-type, turtle-excluder device, or TED (right). *Harvesting Systems and Engineering Branch, Mississippi Laboratory, NOAA Fisheries.* **LEFT:** Fishermen, scientists, and shrimp farmers sign up for a Corpus Christi, Texas, workshop on the hazards of shrimp aquaculture. *William B. Folsom, NOAA Fisheries.* **BELOW:** Florida Bay looks serene but is vulnerable to pesticide contamination from Everglades runoff. *William B. Folsom, NOAA Fisheries*

however unintentionally. The mandated use of TEDs has improved sea turtle survival, but the still-heavy bycatch of young red snapper and other fish that are the same size as the target shrimp continues to raise the hackles of snapper fishermen.

Shrimping, like most other fishing, isn't just a job. It's a way of life that is becoming increasingly difficult. Thousands of coastal families depend heavily on shrimp for a living, however small their individual harvests. Few other types of employment are available to them. Since the crash of the 1960s–1970s offshore Gulf of Mexico oil industry, which had provided many good jobs, alternative work is very hard to come by in coastal Louisiana and Texas for either out-of-work shrimpers or their spouses. Fishing for other species isn't a good alternative: shrimp boats can't easily be converted from trawling to other fishing methods, and most other valuable Gulf resources are already fully utilized anyway.

Another looming threat is the impact of the loss of coastal wetlands on wild shrimp production. The abundance of shrimp depends on the health of the marshes and estuaries needed for early growth of the shrimp. This habitat has been undergoing great degradation over recent decades, although the effects aren't the same everywhere. For example, pesticide contamination and lack of freshwater runoff from the Everglades into Florida Bay present a menace to the state's important pink shrimp fishery. In the northwestern Gulf, marsh alteration arising from engineering projects and sea level rise has created more marsh edge and provided greater protection from predators; as a result, brown shrimp production has expanded. Over the long run, however, continued subsidence may well lead to the loss of wetlands and, most likely, to a decrease in fishery yields, although this isn't evident so far. Similarly, channels that were cut across Louisiana and Texas marshes in the 1960s to accommodate oil and gas pipelines may lead to an eventual loss of shrimp and finfish nursery grounds.

Although not nearly so large as the penaeid shrimp fisheries, the Gulf of Maine's northern pink shrimp is important, especially as frozen product for markets in Europe and Asia. These little coldwater gems are the ones commonly used in Japanese sushi, Scandinavian open-face

LEFT: For more than 100 years, the versatile shrimp has been a favorite American seafood. © *William B. Folsom Photography, Inc.* **RIGHT:** A respectable catch of coldwater northern shrimp is unloaded in Portland, Maine. © *Nance S. Trueworthy*

shrimp sandwiches, and American shrimp salads. There are also growing markets in China and Britain for these flavorful shrimp, and in spite of heavy competition from Pacific Northwest shrimpers and from Canada, Iceland, Greenland, and Norway, demand is always strong. The resource is managed under the auspices of the Atlantic States Marine Fisheries Commission, and harvests are generally at about the level where significant additional pressure would lead to overfishing.

Most of the coldwater shrimp catch occurs during the winter and in often-rough offshore seas, but New England shrimp trawlers aren't particularly large. And though trawl gear for the species is markedly different from that used for their penaeid cousins, Northeast shrimpers have also had to solve the problem of heavy bycatch (in this case, young cod, haddock, and flounder). The size of coldwater shrimp—much smaller than the finfish that associate with them—has led to a ready solution to the problem. Virtually all Northeast shrimpers today are required by federal regulation to use the "Nordmore grate," a grid-like device that permits the finfish to escape while almost all the smaller shrimp pass through the grate into the bag.

A small amount of U.S. shrimp production also comes from aquaculture. For decades, many states in the Southeast have been involved with culturing this resource, but the majority of farm production—still a tiny fraction compared with the crops produced in Latin America and Asia—is from Texas. Experimental culture in the 1970s and 1980s helped establish growing requirements, and U.S. producers, aided by extensive federal grants, became especially adept at providing the world with "seed shrimp," which are used for breeding. But shrimp farming is still labor-intensive, making it more costly in the United States than in many countries with low labor costs. The industry also faces a serious hazard from introduced diseases that can wipe out acres of ponds in a very short time. In addition, some people fear that wild shrimp stocks may be jeopardized by escaped farmed shrimp spreading disease or eroding the genetic diversity and hardiness of native species.

Lobster

New England lobster, more properly known as American lobster, is arguably the best known culinary icon in the world, considered by many the king of seafood. Nearshore traps ("pots") have taken the animals for hundreds of years, but strong demand for this resource has also led to some trawling and to an infant lobster aquaculture industry in Martha's Vineyard, Massachusetts. The offshore

The estimable American lobster has been prized as a premium seafood for centuries. © *William B. Folsom Photography, Inc.*

1

AMERICAN LOBSTER: ONE RESOURCE, MANY FISHERIES

Historically, many fisheries have focused on a single species, with their practitioners becoming highly skilled in finding and catching their target. This is the case with the American lobster fishery, although some would argue that the great variety of gear—traps, trawls, impoundments, and hand-harvesting—actually make this many different fisheries.

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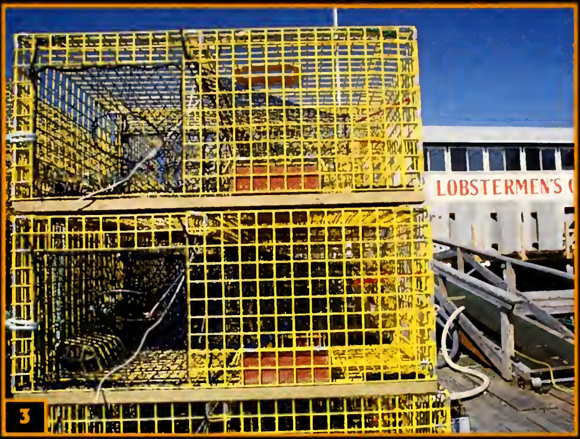


3

1 Nineteenth-century dory fishermen haul wooden lobster traps off Cape Ann, Massachusetts. *From a photograph by T.W. Smillie. The Fisheries and Fishery Industries of the United States, NOAA Fisheries.* 2 Few seafoods can light up a diner's face like the traditional New England boiled lobster. © *William B. Folsom Photography, Inc.* 3 Maine's lobster industry depends on hundreds of thousands of these plastic-coated galvanized wire traps, which are set everywhere along the coastline. *William B. Folsom, NOAA Fisheries.* 4 The imperial lobster—a matchless feast befitting King Neptune himself. © *William B. Folsom Photography, Inc.* 5 Repaired iron-and-wood frames of submerged pound-type pens await return to specially licensed areas off Pt. Judith, Rhode Island. *William B. Folsom, NOAA Fisheries.*

4

Lobster claws are banded to protect handlers—and fellow lobsters—at this market in Jessup, Maryland. *Edward J. Pastula, NOAA Fisheries*

catch, however, is a sore point with inshore trap fishermen, who believe that much of the recruitment comes from offshore.

Lobster brings U.S. fishermen about $240 million a year. About 80 percent of the catch is taken in Maine and Massachusetts nearshore waters, and commercially fishable amounts extend as far south as New Jersey. There is also an important offshore fishery in Rhode Island, and a coastal fishery in New Jersey. And in spite of the Northeast's frigid waters, which usually limit scuba activity, recreational divers in New York can be found diligently searching for the "big bug."

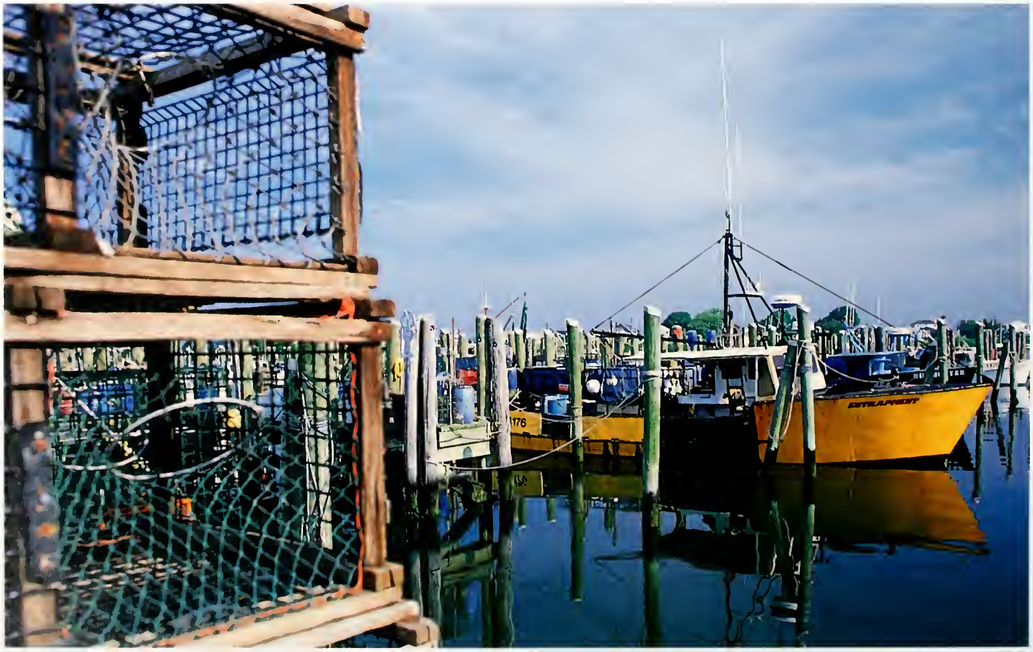
The great abundance of these giant-clawed crustaceans in American waters amazed—and delighted—colonists. Captain John Smith's 1614 observation about lobster is telling, presaging its subsequent use primarily as cod bait in colonial America:

> "Lobsters are there infinite in store in all parts of the land & very excellent. The most use that I made of them, in 5 yeares after I came there was but to baite my Hooke for to catch Basse, I had bin so cloyed with them the first day I went a shore."

In earlier eras, the market for lobster as a human comestible was limited. The difficulty of transporting live animals meant that most lobsters were either consumed locally (four-foot, 45-pound specimens weren't uncommon) or, in the 19th century, packed into tin cans. Today, most of the catch is marketed alive and often shipped long distances packed in seaweed or seawater-soaked newspaper, although frozen, whole, cooked lobster is also a common product. In spite of lobster's relatively high price, demand for it has climbed steadily, with 1990 landings being more than five times higher than the catch in 1940. The trade is mostly for 1–1½-pound animals, although giants up to 25 pounds occasionally grace restaurant lobster tanks (establishments commonly don't sell such behemoths, but keep "Rex," "Big Louie," or "Boss Newburg" as a whimsical—and effective—device to attract customers).

The American lobster resource is considered overfished. Encouragingly, lobstermen themselves have begun to assume a dominant management role in their fishery. Management is mostly by the states, coordinated by the Atlantic States Marine Fisheries Commission, but there is also considerable federal involvement. Management measures include a moratorium on new entrants, seasonal closures, minimum sizes, and requirements for traps to permit the escape of undersized lobster.

Pt. Judith's small lobster boats set pots in Long Island Sound, while the larger Rhode Island boats fish offshore. *William B. Folsom, NOAA Fisheries*



LEFT: A Pt. Judith, Rhode Island, bait seller strings skates for sale to local lobstermen. *William B. Folsom, NOAA Fisheries.* **TOP RIGHT:** With thousands of traps lost to the sea each year, a Maine lobster trap maker is guaranteed permanent work. © *Nance S. Trueworthy.* **BOTTOM RIGHT:** The reclusive Caribbean spiny lobster is eagerly sought, but hard to coax from the protective reefs. © *Brandon D. Cole*

Another major problem is the overcapitalization of the fleet. Many thousands of boats work these northern waters, reflecting every lobsterman's dream: to own his (and often, her) own boat. The result is an immense number of traps cluttering the fishing grounds, with many lobstermen tending more than 1,000 traps at a time. Most admit that they'd be happy with regulations limiting the number of these expensive traps for everyone, and this may happen within a few years.

The overall cost of trap lobstering, which is not very fuel-intensive, is nevertheless quite high as a result of the many pots and buoys that are lost or damaged each season. Lobstermen must also buy bait for their traps, and this need has spawned profitable bait industries at lobster boat docks. Bait companies commonly buy the bycatch of local draggers—usually skate and herring, but other oily fish are also used. Several pieces of bait are strung on a line and heavily salted in large plastic drums. As with other fisheries that depend on bait, the lobster fishery provides income and employment not only to bait sellers but to the salt and plastic barrel industries as well.

In addition to overharvesting, heavy equipment costs, and too many participants, lobstermen have other troubles. Dockside prices fluctuate widely, depending on weather and ocean conditions and on the availability of imports from Canada (which generally make up about half of the lobsters consumed in America). And recently, the army of lobstermen found itself in a fracas over interactions with the endangered right whale. While entanglement of these giants with lobster pot buoy lines is exceedingly rare, so are the right whales; with fewer than 300 of these animals in the entire North Atlantic, even one death is significant in recovery efforts for the species. Although managers had to impose regulations on fishing areas and methods, these measures specifically encouraged the development of gear to help lobstermen and whales coexist peacefully.

Though American lobster doesn't generally occur in southern waters, a separate species, the spiny lobster, is taken in South Florida and the Caribbean. This tropical relative lacks the meaty claws that must be banded or pegged to keep the fractious and cannibalistic American lobster from tearing others apart. But its flesh is superb, and the resource brings fishermen close to $35 million a year, about one-seventh as much as American lobster. Spiny lobster is taken primarily by fish traps, lobster traps, and divers.

Florida's spiny lobster resource is landed mostly from the state's Gulf Coast and is managed under a joint state–federal plan, with regulations coordinated by Florida. Hundreds of thousands of traps dot nearshore waters, and in spite of efforts to reduce this number, the fishery is still far too heavily capitalized. Partly as a result, spiny lobster is overfished, but contributing to the problem is a lack of information on the recreational take. Recreational diving for lobster may be very substantial—in the early 1990s, more than 140,000 people purchased the state's recreational lobster permit.

Until the resource became scarcer, Caribbean fishermen were sometimes able

Demand for Florida Keys spiny lobster is heavy at dockside restaurants, like this one in Islamorada. *William B. Folsom, NOAA Fisheries*

to catch lobster by merely wading out on the shallow reefs at night with lights. Today, the resource is probably overutilized, more so in Puerto Rico than in the U.S. Virgin Islands. Small lobsters are primarily taken, but if allowed to grow to a larger size before harvest, they'd bring a better price. The early fishery used mangrove-and-chicken wire traps to take both lobster and reef fish, devices that resulted in heavy mortalities of young lobster. More commonly used today are wire lobster traps that are required to have escape panels and other conservation devices. Caribbean spiny lobster is coordinated under a federal plan, but their status is very uncertain. Complicating management is ignorance about the stock structure: the Florida stock is likely of Caribbean origin, swept by currents into the Keys, but it's also possible that all the stocks are distinct.

In addition to heavy harvesting, the lobster fisheries face a unique environmental threat. The reefs and shallow-water algal flats needed by the lobsters for feeding and reproduction are rapidly being lost to coastal development. Another problem contributing to stock declines is caused by the industry itself: some fishermen insist on using live, undersized lobster in the traps to attract larger specimens; this unfortunate custom results in heavy mortality of these juveniles, which may not be legally landed.

Another lobster-like animal also appears occasionally in southern and Caribbean seafood markets, although in very small quantities. This is the slipper ("Spanish") lobster, which looks like a squatty spiny lobster (hence, its other name, the squat lobster). Slipper lobster is usually taken only as bycatch in offshore trawls.

LEFT: Wood-and-wire lobster pots, seen here on a dock at Puerto Rico's Fajardo Beach, are still common in the Caribbean. *Julio A. Serrano, NOAA Fisheries.* **RIGHT:** This 30-foot lobster sculpture in Plantation Key, Florida, is guaranteed to stop traffic … and whet appetites. *William B. Folsom, NOAA Fisheries*

Steamed, spiced blue crabs have an immense and devoted army of fans throughout the Mid-Atlantic. © *William B. Folsom Photography, Inc.* **INSET:** For more than 100 years, small-scale operations have harvested blue crabs along Atlantic and Gulf waterways. *From a drawing by H.W. Elliott, The Fisheries and Fishery Industries of the United States, NOAA Fisheries*

Crab

Two other Atlantic crustaceans have also achieved culinary immortality: the feisty blue crab, far and away the main crab species taken in Atlantic and Gulf waters, and the justly famous Florida stone crab. Small amounts of deepwater red crab, Jonah crab, and golden crab also appear in east coast markets, but blue crab landings are so large that they currently exceed in value all other American domestic crab landings. (This could change if North Pacific king and Tanner crab stocks fully recover.)

Blue crab is, after American lobster and Gulf shrimp, the most valuable of all nearshore fishery resources, including clams, oysters, and all finfish species. This species is the famed Chesapeake delicacy enjoyed as steamed and spiced hard crab, sautéed soft-shell crab, and in the ambrosial Maryland and Georgia she-crab soup. The animals are most abundant from Massachusetts south, with areas of greatest productivity in Chesapeake Bay and in the sounds and marshes of North Carolina and Louisiana. Together, east coast and Gulf of Mexico blue crab brings fishermen almost $150 million a year. The industry also has a considerable local labor force of buyers, processors, and pickers, although the work is seasonal.

Blue crab was harvested by Native Americans as well as by European colonists, but commercial exploitation didn't begin until the introduction of industrial canning in the mid-19th century. Vast numbers of blue crab are taken in pots, but because of its famous tenacity in holding onto a bait, it's also commonly taken with trotlines—the baited longlines without hooks. Most commercial crabbing today is done from small vessels, but 19th-century crabbing (as well as oystering and some finfishing) was done from the celebrated Chesapeake "skipjacks," the graceful sailboats that worked both shallow inlets and the bay's deeper waters. A few working skipjacks are still in use, but most of the venerable craft have been converted for tourist pilgrimages to the days of Chesapeake glory.

There are also enormous recreational and subsistence catches of blue crab, though none of them are monitored or recorded. A piece

The nation's capital attracts swarms of crab-lovers to its riverfront market steamers on warm summer evenings. *Edward J. Pastula, NOAA Fisheries*

CRABS
COOKED CRABS
Capt. WHITE
SEAFOOD CITY
RAW BAR

LEFT: Visitors to the east coast are often startled when they realize softshell crabs are to be eaten shell and all. © *William B. Folsom Photography, Inc.* **RIGHT:** A well-gloved worker in a Washington, D.C., seafood market demonstrates blue crabs' tenacious grip. *Edward J. Pastula, NOAA Fisheries*

of string and a chicken neck or skinned-out fish carcass is all it takes to yield quite a few crabs in an hour's work. From spring through fall, just about every coastal slough and tidal creek boasts crabbers of all ages and from every economic stratum. Professional or recreational, crabbers are readily identifiable by the puckered thumb scars and outlandish yarns about the little beast's unyielding grip.

Taken primarily in nearshore waters, the blue crab resource is managed by the states, although there is considerable research and management coordination in Chesapeake Bay because of the widely fluctuating yields. Overall, the resource is considered fully utilized. Recent poor yields in some areas, though, are blamed on local overfishing, predation by weakfish and the now-abundant striped bass, loss of aquatic vegetation needed for habitat, and pollution. On Maryland's Eastern Shore, watermen decry the common practice of giving all waterfront property owners permits for one or two crab pots; as bay-front and creek-side vacation housing has swelled, some crabbers insist that the influx of new pots has led to an overall decrease in the stock. Blue crab abundance has actually increased in Delaware and Raritan Bays, and there are other spots of localized abundance.

The demand for softshell blue crab has generated a spinoff industry. Soft crabs—those in the process of moulting—are seldom taken in the regular fishery, since the animals neither hunt nor eat during this shedding period that lets them grow. In the mid-1850s, New Jersey crabbers found they could hold hard crabs in shoreline pens until they moulted, but these early attempts at a softshell industry failed because of overcrowding, injuries from the pugnacious animals' battles, and other reasons. The solution has been to scoop up the "peeler" crabs—crabs that will shed their entire shell within a day—from the eelgrass beds where they hide prior to moulting. They are transferred gently to dockside holding pounds, and after moulting, are shipped to market alive, packed in ice and eelgrass or other moist materials. Today, there are literally hundreds of dockside crab-shedding businesses, most of them small "mom-and-pop" operations.

More curious as a side industry are the raucous crab festivals and derbies held in many Chesapeake communities. Although blue crabs are good swimmers, they are also notorious runners and climbers. Brazen escapes from crab baskets and boxes are a common occurrence aboard vessels, on the

LEFT, INSET: To many crab aficionados, Florida's stone crab is the standard against which all other crabs are compared. © *William B. Folsom Photography, Inc.* **BELOW:** Few seafoods have the éclat of Florida's stone crab, with entire restaurants devoted to this one product. *William B. Folsom, NOAA Fisheries*

docks, and even in processing plants. Capitalizing on this penchant, the crab run is planned pandemonium, where crabs freed from little starting gates scrabble wildly down a course in the apparent belief they're going somewhere. But they can clock very respectable times if they don't stop to torment fellow racers. Especially valiant champions are sometimes ceremoniously returned to the bay, but also-rans are generally consigned to a last moment of glory in a bit of melted butter.

ABOVE: A crew in Portsmouth, New Hampshire, unloads bushels of relatively scarce rock crab. © *Nance S. Trueworthy.* **RIGHT:** Horseshoe crab, here beached in Delaware after spawning, is harvested for both bait and biomedical research. © *William B. Folsom Photography, Inc.*

Landed in far smaller quantities than blue crab, but with its own battalion of devoted followers, is the stone crab. The fishery, which brings crabbers up to $27 million a year, occurs primarily in the Keys and northward in the Gulf to Cedar Key, although some are also taken in Texas. A similar species is imported from Mexico and Central America to help supply the restaurant demand. Stone crab is taken only in traps, and savored exclusively for the meat in their large claws. The crab's offer of such a limited product has a distinct advantage for both itself and the crabber: usually, only one claw is removed before the animal is set free, and it may live to spawn—and see later capture sporting a regrown appendage.

Stone crab is managed under a federal plan that permits Florida to regulate catches in both state and federal waters. Egg-bearing females and undersized crabs are stringently protected, and traps must now have biodegradable panels to prevent "ghost fishing" by lost traps. The fishery still has problems, though, especially the threat of degraded water quality and flow through the Florida Everglades. Without a comprehensive Everglades water management regime, stone crab productivity may decline.

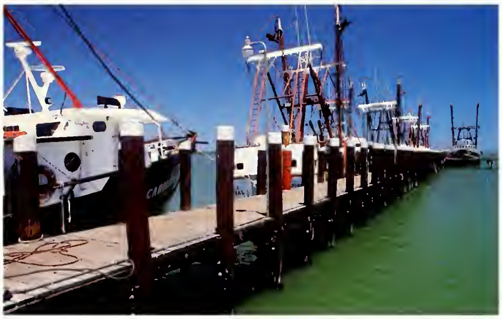
Other Atlantic crab species are taken only in very small quantities. Red and Jonah crab are taken by a few fishermen along the New England coast in modified lobster traps. Deepwater red and golden crab may also occur in concentrations at 600 feet or more, but aren't landed in any great numbers. And the nearshore green crab, although too small for ready marketing except as bait for anglers, has another—albeit dubious—claim to fame: it's the rapacious predator of small clams in both natural and cultured mollusc beds.

One other "crab" resource—the horseshoe crab—bears mentioning, although it's not really a crab and is more closely related to spiders and scorpions. Seen at times in enormous inshore concentrations in Delaware Bay and elsewhere in Mid-Atlantic shallow-water areas, horseshoes are found along the entire Atlantic Coast. A small but critical portion of the horseshoe crab catch is used for biomedical research on human blood and eyes, wound healing, and detection of bacteria in drugs; a small portion of their blood is extracted, and they're then released alive. Horseshoe crab is also a crucial food for migrating shorebirds and young loggerhead turtles, and is commonly eaten by many other marine animals.

There was a substantial horseshoe crab fishery even in the 1800s, with most of the catch used for fertilizers and livestock food. There is a growing use of horseshoe crab as bait in the eel pot and conch fisheries, but, in fact, it's been heavily overfished for many decades. Some states are now actively regulating catches—New Jersey has banned its take in the state's trawling fleet, Maryland has restricted catches, and the species has been proposed for coordinated management under the Atlantic States Marine Fisheries Commission.

Sea Scallop

The offshore sea scallop resource is by far the most valuable mollusc fishery in the Northeast, although the commercial fishery didn't really develop until the beginning of the 20th century. This buttery delicacy (along with the smaller but far less common bay scallop) is the famed coquille St. Jacques harvested from North Carolina north to the Hague Line separating U.S. and Canadian fishing grounds. The prime U.S. scalloping grounds are the Gulf of Maine, Mid-Atlantic Bight, and Georges Bank. New England sea scallop landings account for almost half the total Atlantic



ABOVE LEFT: Locally caught scallops are a specialty of coastal restaurants, like this one in Pt. Pleasant, New Jersey. *Edward J. Pastula, NOAA Fisheries.* **LEFT:** Seaford, Virginia, is home to a large and modern fleet of scallop dredgers. *William B. Folsom, NOAA Fisheries.* **ABOVE:** Workers sort scallops by size at a waterside processing plant in Seaford, Virginia. *Edward J. Pastula, NOAA Fisheries*

take, but one port, New Bedford, accounts for a full third of the New England harvest. Scallops are also landed at other ports: Newport News and Hampton in Virginia, Cape May in New Jersey, and Wanchese in North Carolina.

Most scallop is harvested by large specialized vessels that make trips of 10 to 15 days. The boats sport huge bottom dredges—metal frames with a chain-like bag made of metal rings and with a twine top—although Mid-Atlantic scallopers also use trawls. The dredges are best suited for some bottoms that would damage trawl nets, but trawlers work well in smooth areas and offer the advantage of easy conversion to finfish and shrimp trawling when scallop is scarce. Unfortunately, trawl nets also have a much higher bycatch of undersized scallop. Valued fish species are also taken, and a growing problem for both trawls and dredges is the high bycatch mortality of goosefish (monkfish) that inhabit the scallop beds.

Scallop has been considered heavily overfished for some time. It's a difficult resource to manage, in part because the abundance varies so widely by area and year. The strong landings of the early 1990s have been offset by subsequent years of poor recruitment, resulting in lower landings. The resource still brings fishermen more than $100 million a year. Scallop is federally managed, with current measures consisting of mandatory ring sizes and allowed number of days at sea.

The industry has also been plagued by the practices of a few unscrupulous fishermen and dealers. Scallop is generally sold by the "meat count," the number of shucked meats per pound. Freshly shucked scallop can absorb quite a bit of water, increasing their appearance and weight, although purposely soaking it is fraudulent and illegal. Inspectors and enforcement agents check batches regularly for this serious violation, but unfortunately, buyers and processors sometimes unknowingly end up with such doctored meats from the imports that today play a substantial role in meeting America's demand for scallop.

Clam

Both New England and the Mid-Atlantic are deservedly famous for their clam resources. There is a common public image of gnarly diggers plodding through tidal flats with quaint clam buckets, but in reality, the resources are largely harvested using dredges, or are cultured. Three Atlantic species are responsible for most of America's clam harvest: the ocean quahog (pronounced "co-hog"), surfclam, and hard clam. Clam nomenclature has always been confusing. For example, hard clam is sometimes known as "northern quahog," but landings reported for quahog refer to the ocean quahog, a separate species. And ocean quahog is sometimes also called "cherrystone" when smaller, while hard clam is also known as "little neck."

For centuries, hard clam has been a favored eastern seaboard dish. However, it wasn't until processes were developed in the 1960s to moderate the strong flavor of quahogs that this resource, too, became popular. Today, quahog is often used for the stuffed clams and clam cakes served everywhere on the east coast. New Jersey's canneries use a large part of the surfclam and ocean quahog resources, producing chowder, clam juice, and minced clam, and the

Littleneck clam is only one of several species used in the making of that great American classic, clam chowder. *© William B. Folsom Photography, Inc.*

LEFT: Freeport, Long Island, clam boats share dock space with vessels fishing squid, flounder, and other coastal species. *Edward J. Pastula, NOAA Fisheries.*
ABOVE: Essex, Massachusetts, has a long clamming history, as shown in this 19th-century commercial shucking operation. *From a photograph by T.W. Smillie, The Fisheries and Fishery Industries of the United States, NOAA Fisheries.*
RIGHT: Steamed softshell surfclams are an eastern delicacy, and the meats also find a ready market for canned chowder. *William B. Folsom, NOAA Fisheries*

two species together return almost $60 million a year to fishermen. Hard clam, however, commands a far higher price per pound than either quahog or surfclam, bringing fishermen about $50 million a year. As with other ocean molluscs, clam yields can vary greatly as a result of both natural environmental conditions and fishing pressure.

In the 19th century, most surfclamming was in Cape Cod, especially Wellfleet, with the clam beds harvested by the small catboat dredges of Finnish immigrants. A hefty portion of today's surfclam harvest is taken off New Jersey and the Delmarva Peninsula, although some is also harvested in southern New England, Long Island, and the Gulf of Maine. Hard clam is primarily a nearshore species, while surfclam (belying the species' name) occurs in the greatest concentrations offshore. Quahog is abundant offshore, but also found relatively nearshore in the Gulf of Maine and other coldwater areas. Large numbers of surfclam and ocean quahog occur on Georges Bank, but harvesting of these species is prohibited there because of paralytic shellfish poisoning (PSP). Hard clam fisheries have also suffered substantial losses as a result of parasites that cause heavy mortalities.

Though none of the three main species is overfished, they probably can't withstand greatly increased fishing effort. While hard clam is managed by the individual states, quahog and surfclam harvests are regulated under a single federal plan that allocates individual transferable quotas (ITQs) based on historical participation in the fisheries. In fact, these were the first individual quota fisheries in the United States, and it took many years of wrangling between industry and fishery managers to get them in place. The plan anticipated—even desired—consolidation of vessels and processing plants and, indeed, that's what has happened. There are now many fewer boats and plants than before the ITQ fishery, but as intended, supplies and prices have stabilized. Of course, there is a darker side to this, as with most individual quota fisheries: some would-be fishermen have been shut out, and some with quota shares feel they were pressured by the new economics to sell their portions.

Another species, the softshell clam, supports small nearshore fisheries in Maine and Maryland. Together, landings of softshells bring fishermen about $10 million a year. This represents a substantial decline since the late 1960s, although it has resulted from natural conditions and not because of overfishing. For unknown reasons, reproduction of young softshell clam in northern Maine has been very poor, while the recent high clam mortalities in

At a Kent Narrows, Maryland, processing plant, a worker ices down steamer clams to keep them alive until cooking. *William B. Folsom, NOAA Fisheries*

Maryland are attributed to unusually hot summers.

The issue of shellfish safety bears some discussion. Because they're "filter feeders," clam, oyster, and mussel are particularly susceptible to the dire effects of certain pollutants and the toxic algal blooms known as brown tides and red tides. These outbreaks usually occur in areas where farms and sewage leach their nitrogenous wastes into coastal soils and waters. Clam tissues are especially prone to storing high levels of toxins, even though this doesn't normally harm the molluscs themselves. One such toxin leads to PSP and can debilitate or even kill humans who eat contaminated clams. An even more deadly—though rare—toxin, domoic acid, can leave its victims permanently deranged and unable to control bodily functions. Most commercial clam beds are routinely sampled for these toxins and can be closed if concentrations exceed allowable levels. Some inshore areas have also been closed because of oil spills and, occasionally, because of contamination from such pathogens as cholera and *E. coli*. Although molluscs in these beds should not be eaten, they can sometimes be transplanted to cleaner "sanctuary" areas for spawning purposes.

Aquaculture offers great promise for increasing the production of clam, which does well under conditions of crowding. Shoreside clam farms are scattered throughout New England—in Duxbury, south of Boston, and in Provincetown, Wellfleet, and Chatham on Cape Cod. Most farmed clam, usually thought of as a Northeast delicacy, is actually bred from hatchery seed and grown in the South, where a mild climate and nutrient-rich waters permit year-round harvests. The rich marshlands of South Carolina see an abundance of hard clam, and it's also extensively cultured in Florida's Indian River area.

As with all fish farms, the culturing of clam gives its practitioners a hefty share of headaches. Clam is subject to environmental perturbations and climate variability, and plenty of diseases, parasites, pollution, and predators—especially starfish and green crab. Ducks and other aquatic birds offer a particularly difficult problem, in that many of them are migratory and are protected under federal law. One interesting solution to predation has been the method adopted in Charleston, South Carolina, of growing out the clams in baskets suspended above the mud; the clams are able to filter feed, but crabs, birds, and other would-be clam eaters can't reach them.

Oyster

Among the Atlantic's great molluscan treasures is the sumptuous oyster, long a valuable nearshore fishery and now bringing Atlantic Coast and Gulf of Mexico fishermen about $135 million a year. After decades of decreased yields caused by overfishing, disease, and pollution, oyster beds are beginning to flourish again in parts of the two main Northeast production areas—Delaware and Chesapeake Bays. Long Island Sound is also a major production area, with the justly famous blue point arguably holding oysterdom's place of honor, and beds are abundant in many Gulf areas.

BELOW: Littleneck clams grown out in marshside pens are rinsed at a clam farm in Folly Beach, South Carolina. *William B. Folsom, NOAA Fisheries.* **RIGHT:** Live hard clams are transported in mesh bags and meticulously documented to ensure their wholesomeness. *Louise Kane, courtesy Office of Habitat Conservation, NOAA Fisheries*

ABOVE: On the half shell (shown here) or deep-fried, oysters remain one of America's great luxury seafoods. © *William B. Folsom Photography, Inc.* **LEFT:** The unique and graceful Chesapeake skipjack, symbol of yesteryear's oyster and crab fisheries. Courtesy of Gene Cope, *NOAA Fisheries*

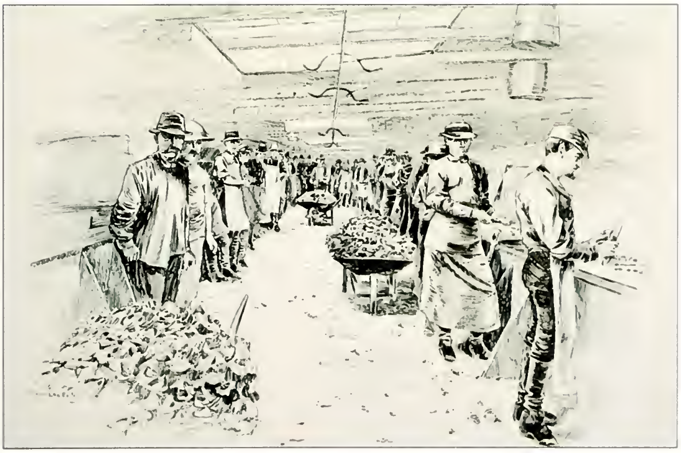
For centuries, oyster was celebrated by the Dutch and English before these people settled in the New World, where they found the native inhabitants already harvesting them. Generations of oystermen gathered the molluscs with wood and metal tongs and with other simple devices worked from shallow-draft boats and, later, the famous Chesapeake skipjacks. By the late 19th century, fishermen on steam vessels used dredges that permitted them to bring up oyster from deeper waters. Today, Chesapeake watermen still "drudge" up the molluscs, but large suction devices are increasingly common everywhere the oysters are harvested.

Chesapeake oyster yields peaked in the 1880s. The Atlantic harvest today is a tiny fraction of that—about 1 percent. The growth of the industry in the mid-19th century was largely fueled by the expansion of railroads throughout the nation, making possible the shipment of live oysters far inland, where the demand for them was great. Oyster was actually cheaper than beef or chicken or even fish, making them popular even with poor people. By the turn of the century, Chesapeake Bay and the Potomac River were the sites of the brutal "oyster wars," with thousands of Maryland and Virginia watermen battling over harvesting rights. Disputes continued until only a few decades ago, when heavy exploitation, unfavorable weather and ocean processes, pollution, and disease (the "MSX" *Haplosporidium* parasite and the waterborne pathogen "Dermo") had nearly wiped out the entire resource in the region.

Along with the disappearance of this remarkable little filter-feeder has been Chesapeake Bay's ability to cleanse its pollutants and silt. There is a serious effort today to restock the Bay with disease-resistant "spat," or seed oysters, and to clean up heavily polluted areas that were once rich with the molluscs. But if oyster is coveted by seafood lovers, it's just as tempting to a host of predators: starfish, oyster drill (snail), skate and other fish, and shore birds—anything that can break into the tough shells.

The Southeast—North Carolina south to Georgia, and in the northern Gulf of Mexico—also produces very fine oyster, about 57 percent of the total Atlantic harvest. Yields there have also suffered from overfishing and pollution. The formerly large Louisiana oyster harvests, in particular,

Men and women shuck oysters in a Baltimore packing house in this 19th-century engraving. *From a photograph (photographer unknown), The Fisheries and Fishery Industries of the United States, NOAA Fisheries*



FAR LEFT: Piles of shells are destined as habitat for the next generation of larval oysters in St. Michaels, Maryland. **NEAR LEFT:** Tons of bagged blue point oysters are trucked to market from shoreside beds near Norwalk, Connecticut. **BELOW:** This small Norwalk, Connecticut, boat services beds of the privately owned and justly famous blue point oysters. *Photos by William B. Folsom, NOAA Fisheries*

EBEN A. THACHER

are currently very small because so much of the acreage devoted to beds is badly polluted, making it illegal to harvest or sell these oysters. Although the Gulf Coast is rich with oyster habitat, it poses a particular environmental conundrum: when rain is light, favoring good shrimp yields, there is often an explosive growth of the rapacious oyster drills that thrive in the now-salty estuarine areas. Oyster is also heavily preyed upon by such fish as black drum, boring clam and sponge, mudworm, blue and stone crab, and starfish. And as a final insult, they're vulnerable to a host of suffocating growths—barnacles, algae, shells, worms, and many other organisms.

There are still many productive areas, however, and Atlantic oysters are shipped throughout the country, even to the Pacific Northwest, which harvests excellent oysters of its own. Most oyster is mechanically opened in shucking plants and frozen for shipment throughout the country. A great many are also hand-shucked in oyster bars and seafood restaurants for the millions of aficionados ecstatically slurping them raw (against the good advice of the health care experts—these uncooked molluscs can harbor pathogens that cause serious illness).

In general, oyster is considered overfished. The resource is managed by the states, with regulations quite specific to each. For example, Maryland watermen may dredge under power only on Mondays and Tuesdays, and for the rest of the week, must work under sail—which is so inefficient that most fishermen simply don't work then. Many Atlantic and Gulf of Mexico oyster beds are managed under long-term leaseholds, with generations of a family having the sole harvesting rights on some tracts. Other beds are leased from the states, and in Long Island Sound off Connecticut, blue points are transplanted, grown out, and heavily monitored by a single firm that has "owned" the beds for more than 100 years.

Because many Atlantic oyster beds are so carefully seeded and tended, that resource might better be considered as a cultured product. Oyster was probably the first American fishery resource to be cultivated. By 1850, many natural oyster beds had been leased to private companies that not only raised the animals, but collected oyster brood for restocking the beds. Today, oyster dominates the nation's shellfish culture (followed by clam, mussel, and shrimp, with lesser amounts of abalone, scallop, and lobster).

Other Molluscs

Most other mollusc harvests along U.S. Atlantic shores are small compared to their importance worldwide. Blue mussel, produced in Maine and Massachusetts, fits the strictest definition of aquaculture: it's spawned, settled, tended, and harvested in carefully controlled "farms," although a small amount of the wild resource is also taken. The market for mussel has grown rapidly in recent years, commensurate with the demand for the fine French, Italian, and Spanish cuisines that have long valued the plump orange meats. Unfortunately, devastating storm damage to the Nantucket Island (Massachusetts) mussel beds greatly reduced production in the early 1990s, leaving Maine as the chief producer today. Even with higher prices, mussel, which is grown out on multilevel rafts, is still one of the best seafood values around.

Except for clam, mussel, and oyster, most other harvested Atlantic molluscs haven't been cultured to date, but are collected from naturally occurring beds subject to wide variability in productivity. Thus, the very small bay scallop fisheries in Rhode

THE SHELL MA

FAR LEFT: A specialized vessel readies Maine's blue mussels for seeding in prepared shoreside areas. © *Nance S. Trueworthy.* **TOP LEFT:** Their tender meat and reasonable price have made cultured Maine mussels popular in both home kitchens and restaurants. © *William B. Folsom Photography, Inc.* **BOTTOM LEFT:** A Florida Keys shop boasts queen conch shells, but the species is badly overfished in both Florida and the Caribbean. *William B. Folsom, NOAA Fisheries*

Island and on eastern Long Island suffered great losses in the 1980s as a result of dense algal blooms ("brown tides"), and even Massachusetts bay scallop harvests are low as a result of the loss of eelgrass habitat. South Atlantic calico scallop is more common than bay scallop, but occurs in spotty concentrations a tiny fraction of the size of sea scallops beds.

There is, however, a burgeoning conch aquaculture industry in Florida, which hopes to offset imports of conch meat needed to meet the heavy demand in South Florida and the Caribbean. Several species of these large snails are taken, but the primary target is the large and beautiful queen conch, savored for stews, salads, and the enticing conch fritters. Wild queen conch, taken primarily by divers, is severely overfished and under stringent management—in Florida by the state, and in the U.S. Virgin Islands under federal law. Despite the best intentions and efforts, though, illegal takes (often by recreational divers) are common and difficult to detect. A curious note with respect to this beautifully shelled creature: it has the distinction of lending its name to Key West separatists who envision their idyllic setting as the "Conch Republic"—despite the paucity of conch found there today.

Another large snail offered up in the Atlantic realm is the whelk. Though its shell isn't as attractive as the conch, whelk has its own loyal—if small—following from Massachusetts to Virginia. The animals are taken with specialized pots in the Northeast and Mid-Atlantic, although Virginia also has a whelk dredge fishery. Increased harvesting in the last few years has reduced the size of individual animals, but the resource itself isn't believed to be overfished. Whelk, often appearing in markets as "conch," is managed by the individual states.

Still another coldwater snail, the tiny periwinkle, is harvested only in Maine. It has found an enthusiastic market for Asian cuisines, often a prominent feature in restaurants that offer lavish weekend *dim sum* a la carte feasts. Periwinkle landings have declined slightly in recent years, and fishermen have been forced to direct their efforts away from easily accessible inshore areas to the ledges and islands farther offshore.

The homely but tasty whelk needs healthy marshes for its survival, like this one in North Carolina's Albemarle Sound. *William B. Folsom, NOAA Fisheries*

Fishermen from Pt. Pleasant, New Jersey, now target squid and other resources because of groundfish declines. *Edward J. Pastula, NOAA Fisheries*

Although fishable concentrations of squid aren't found in the Gulf, the Atlantic Coast stocks bring fishermen about $30 million a year, almost as much as the Pacific squid fishery. Much of this catch is destined for Europe, but there is also a growing market for squid in the American restaurant trade—it's an important staple of Italian, Portuguese, Spanish, and Basque cookery, as well as just about every Asian and Latin American cuisine. In addition, squid has long been important as bait for both commercial and recreational tuna and swordfish fisheries. Most squid is trawled up in winter in the Mid-Atlantic Bight and southern New England, but squid boats also frequently target whiting (a small codlike fish), mackerel, and other species, depending on what's available and what the market will bear. Both short- and long-finned squid are believed to be fully utilized resources.

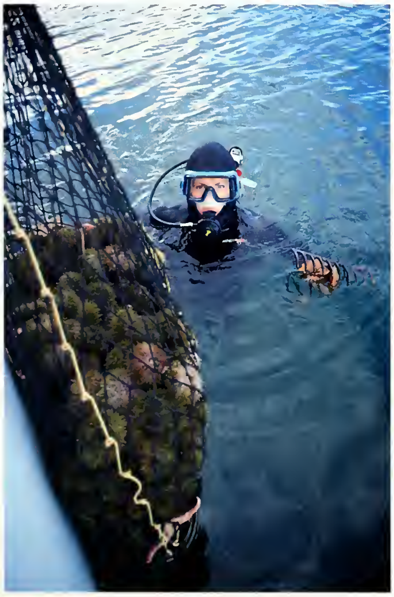
Other Invertebrates

Many people are surprised to learn that the second largest landings among Northeast nearshore species, after blue crab, are for sea urchin. The prickly resource has been subjected to increasing fishing pressure since a major Maine fishery began to supply the Japanese roe market in 1987. Urchin, under state management, is harvested by divers, and the relative ease of gathering it has resulted in some local areas being fished out.

A fishery for sea cucumber (a relative of the sea urchin) has also recently sprung up in Maine to supply expanding Asian-American communities and markets in the Far East. Sea cucumber is currently abundant, as fishing is being conducted on virgin stocks. But without some sense of the resource's size, it could rapidly be depleted.

Like so many Northeast marine resources, sea worm has declined both in abundance and in average individual size because of heavy harvesting. Sea worm, harvested primarily in Maine, is highly sought as bait by recreational fishermen everywhere along the eastern seaboard, but worm diggers, who have traditionally been paid by weight landed, are now demanding higher prices because of lower worm supplies.

The Florida sponge fishery, historically confined to the Keys and Tarpon Springs, reached its peak at the turn of the century with the immigration of experienced Greek sponge fishermen to Florida. Whereas the sponge was earlier taken in shallow-water reefs, special schooners and other vessels that sported wide beams and light drafts let the fleet expand to waters almost 100 feet deep. Even in the early 1890s, harvesting was by helmeted "hard hat" divers supplied with air from onboard generators and using small forks and tongs to gather the abundant sponge. The sponge was brought ashore for drying, and distributed throughout the country. The production of synthetic sponge in the 1940s and widespread sponge disease that depleted much of the resource led to the



LEFT: Sea urchin must be harvested by hand—no mean feat in the icy waters around Maine's Southport Island. © *Nance S. Trueworthy.* **BELOW:** Urchin boats, like this one in Portland, Maine, are usually quite small and crewed by just two people. *William B. Folsom, NOAA Fisheries*

Many people consider the rough spicules and uneven contours of natural sponge superior to the synthetic products. *William B. Folsom, NOAA Fisheries*

sharp decline of the fishery by the early 1950s. Today, only a small amount of natural sponge is taken in Florida; the rest is provided entirely through imports. A few Florida Gulf Coast communities have capitalized on their sponge-fishing history, turning their boats and docks into well-visited tourist attractions.

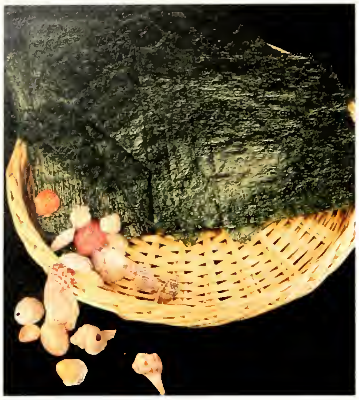
A new fishery has been established for coral found off Florida's Gulf Coast. Both the more commonly known "hard" coral and the soft gorgonian and sea fan were intensively harvested in recent years, until it was recognized that their value as critical habitat for reef species is far more important than their commercial use. Today they're accorded protection from all but a small research harvest. The resource, the oxymoronic "live rock," is still highly valued for the aquarium trade and pharmaceutical industries, and the fishery is trying to maintain a domestic market niche through an aquaculture industry in Florida.

The most recent Atlantic invertebrate fishery is for jellyfish, in particular, the extremely abundant cannonball jelly of the Southeast. Several cooperating boats participate in this five-year-old mom-and-pop-type fishery off Apalachicola, Florida. Assisted by spotter pilots relaying the location of large cannonball "schools," seiners make two-hour hauls of several thousand pounds each, then transport the catch to shore for processing. The dockside price is quite low—only about 10 cents a pound. Since costs to run the small boats and process the wet jellyfish are also relatively low, there are good profits to be made at $1.50 a pound of dried wholesale product. The resource, after a drying and salting process that reduces their watery bulk by 90 percent, has found a steady gourmet market in Asia. Unfortunately, the abundance and distribution of jellyfish are extremely variable: strong winds and heavy seas, or even a bad red tide, can totally dissipate jellyfish concentrations, making fishing impossible. But even a hurricane that kills most of the adult stock has little bearing on the following year's recruitment. The stock tends to spring back unharmed … until yet another weather system causes another bad year. Jellyfish harvesters, however, usually fish for additional species, such as Spanish sardine, to live with these volatile environmental conditions.

Seaweeds

The frigid northern Atlantic waters that favor such an abundance of finfish and shellfish also offer good growing conditions for commercially valuable seaweed. High in vitamin E and antioxidants, seaweed extracts are believed to lower cholesterol, reduce some cancers, and bestow other health benefits on human populations.

One of Florida's few remaining sponge boats returns to Tarpon Springs with the animals drying on a tarp-covered frame. *William B. Folsom, NOAA Fisheries*



Maine is investing in algal cultivation to meet the heavy demand for these processed sheets of *nori*. *William B. Folsom, NOAA Fisheries*

Irish moss, a clustering red alga, has been collected in New England since 1835 for the homogenizing compound carrageenin. The substance has been used as a binding and smoothing agent in food—chocolate milk, ice cream, salad dressings, and puddings—and in health and beauty products, paper finishes, textiles, biochemicals, and pharmaceutical preparations. The relatively pristine "down east" region (coastal northern Maine) normally provides an abundant supply of wild moss, and as it is a slow-growing species, cultivating Irish moss hasn't been considered economically feasible.

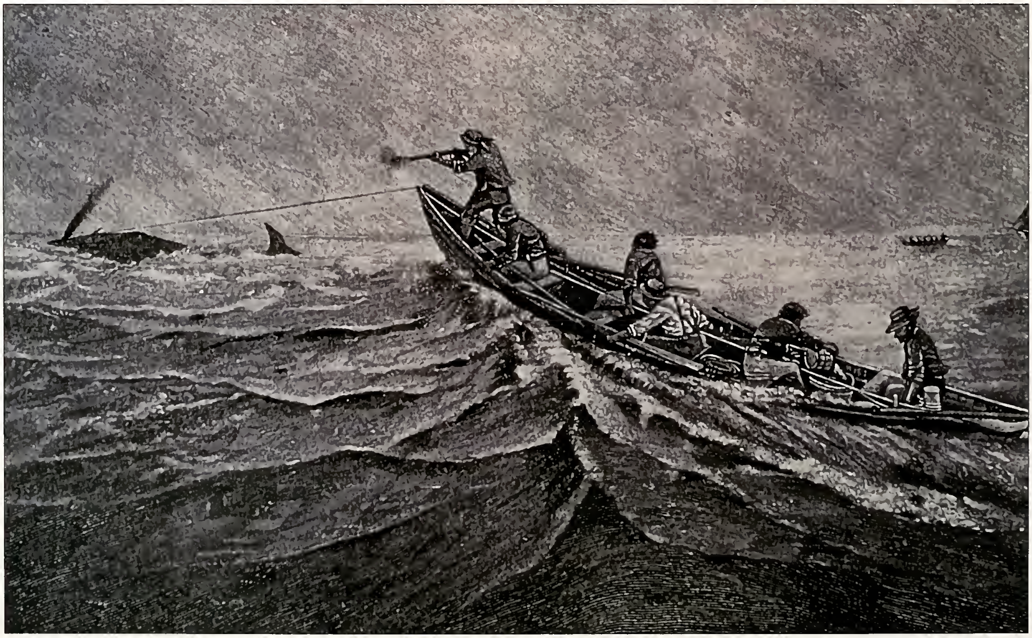
However, a second red seaweed, *nori*, is under intense cultivation in Maine's Cobscook Bay. With its large flat fronds, *nori* grows rapidly and is a nutritious and very valuable crop. Large-leaf seaweed like *nori* is a traditional Asian staple, valued as a flavor enhancer for soups and other dishes. Americans probably know *nori* best as the shiny black sheets used to wrap sushi. The species currently cultivated is a native of Japan, where *nori* culture is a $2 billion industry; researchers are also domesticating wild American species. The potential for a strong *nori* industry is believed considerable, and because cultivation and processing are labor intensive, this new industry may offer work for laid-off regional fishermen.

A small fishery also exists for sargassum weed, a brown alga that is dried and used in poultry feed. Sargassum extracts also may have medicinal and waste-control uses. Unfortunately, large-scale collection poses a real problem to the many juvenile fish (including mackerel and dolphin fish), spiny lobster, shrimp, and sea turtle that need this floating vegetation as protective habitat. Measures to protect the resource from harvesting are forthcoming.

WHALES, SEALS, AND TURTLES

Although the deliberate taking of marine mammals and sea turtles is prohibited today, it is well to recall the role they played in America's fisheries commerce until quite recently. Whaling was by far the more important of these industries, practiced by both pre-Columbian inhabitants and Europeans. Long before the latter settled in the New World, Indians had hunted coastal whales from small canoes. Very soon after their emigration, the colonists entered into the trade to take the black right whales abundant off New

The 19th century's famed "Nantucket sleigh ride" pitted dory against whale until the harpooned animal could be landed. *From a painting by J.S. Ryder, The Fisheries and Fishery Industries of the United States, NOAA Fisheries*



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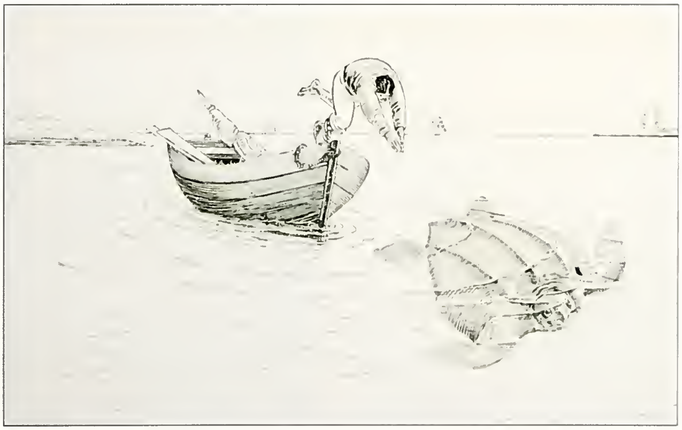
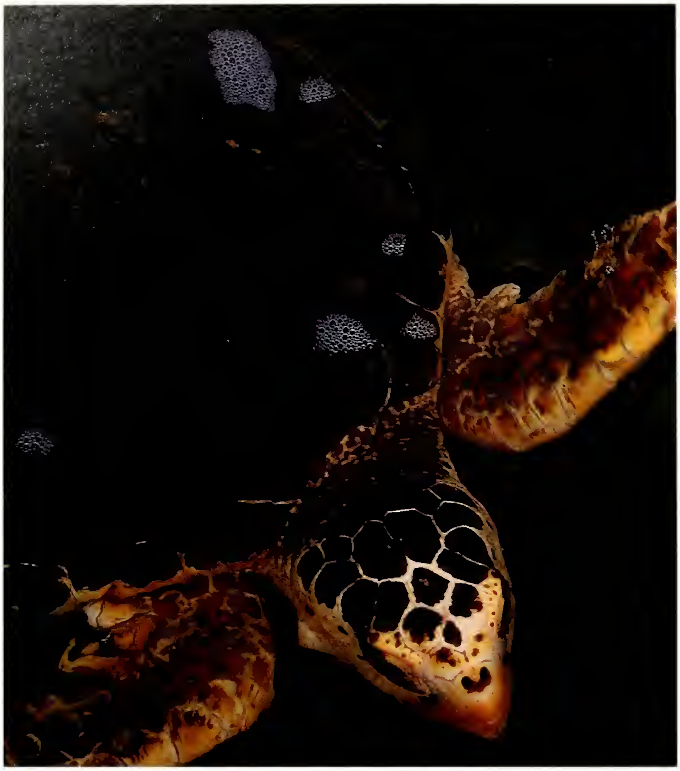
Hurt by groundfish declines, Gloucester, Massachusetts, welcomes tourist dollars from whale watching. *Nance S. Trueworthy, NOAA Fisheries*

England. The late 17th century saw this shore-based whaling centered in New London, Connecticut, and on Long Island. As the animals became scarce, Americans expanded their operations north to Baffin and Hudson Bays in search of right whales for the precious oil needed for lamps, leather tanning, and as a lubricant. Later, the baleen from whales' jaws would be used for corset stays and stiffening collars, and whale oil would be used in the manufacture of margarine as a cheap food. As the right whale stocks also declined, whalers moved onto the high seas in search of sperm whales to extract spermaceti (from the whale's head cavity) for fine-quality candles. Humpback whales were also heavily hunted throughout the oceans. By the 19th century, ports from Boston to Connecticut, with New Bedford the most important, were home to American whaling brigs and schooners.

The golden age of American whaling, in the first half of the 19th century, saw the



TOP RIGHT: Porpoise was once taken in small numbers by the Passamaquoddy and some other Northeast tribes. *From a photograph by T.W. Smillie, The Fisheries and Fishery Industries of the United States, NOAA Fisheries.* **BOTTOM RIGHT:** Nineteenth-century dorymen in North Carolina occasionally took sea turtle wandering into coastal waters. *From a drawing by H.W. Elliott, The Fisheries and Fishery Industries of the United States, NOAA Fisheries*



The little Kemp's ridley, a seagoing reptile that changed the face—and economics—of an entire industry. © *William B. Folsom Photography, Inc.*

take of about 10,000 whales each year. The value of the whale oil extracted from the blubber during a single voyage could exceed the total costs of the ship's construction, operating expenses, and all equipment. After 1850, the number of voyages decreased dramatically along with the whale stocks, the growing use of lighting from the new petroleum industry's oil and gas, and the replacement of whalebone by steel. Even as late as 1970, when *Our Changing Fisheries* (the predecessor of this book) was written, Americans were still whaling, albeit on a very small scale, and importing a great deal of sperm whale oil and spermaceti for fine lubricants and cosmetics. Today, whale-associated activity in the United States is almost exclusively whale watching, but it is a profitable venture, generating $250 million a year. Gloucester, Massachusetts, has added whale-watching cruises to its now tourist-oriented economy, taking thousands of paying passengers to nearby Stellwagen Bank Marine Sanctuary and other nearshore waters that harbor migrating populations of right, humpback, and other whales.

Similar to the whaling industry, which had almost vanished by 1968 and ceased entirely in the 1970s under the International Convention for the Regulation of Whaling, the American fur seal trade grew into a multimillion-dollar industry. Although much of the fur seal take was from Pacific waters, Atlantic pinnipeds—harp, hooded, gray, and harbor seal—were taken by colonial traders as they had been taken earlier by Native Americans. Most American sealing, beginning in the mid-17th century with walrus hunts, was in Newfoundland, Quebec, and other northern areas where the animals concentrated on the ice in huge numbers. However, other countries, especially Norway and Canada, accounted for the vast majority of northwestern Atlantic kills, and by the 20th century, hunts had dramatically depleted seal populations. Stringent domestic management and international treaties have led to recovery of most stocks, but hunts in Canada are restricted for the most part to indigenous groups, and Americans may no longer take seal in Atlantic domestic waters.

If the now-prohibited commercial hunt for sea turtle was neither as extensive nor as lucrative as for marine mammals, yesteryear's turtle fishers at least were equally enthusiastic. There are five Atlantic sea turtle species—loggerhead, green, Kemp's ridley, leatherback, and hawksbill—common along the Southeast coast and in the Gulf of Mexico and the Caribbean. Green turtle was preferred for the flesh, and hawksbill, for the fine tortoiseshell, which could be crafted into exquisite combs, spectacle frames, and jewelry. Turtle eggs, taken from beach nests, were also highly valued. Seagoing adult and juvenile turtles were taken primarily by

A Pascagoula, Mississippi, shrimper crew helps an enforcement officer verify that their TED meets specifications. *William B. Folsom, NOAA Fisheries* harpooning, with the nesting females gathered on shore, but much of the stocks' decimation, especially the Kemp's ridley, came as a result of taking eggs and nesting females. Turtles encountered in bays and lagoons were also sometimes taken in a sort of watery wrestling match that saw the exhausted turtles kept at the surface until they could be hauled ashore. With all the animals listed as either endangered or threatened under the Endangered Species Act, there is no longer a directed harvest. There is, however, still a great deal of nest poaching, and hawksbills are still exploited (mostly illegally) in the waters of other nations.

Few people today are probably aware of yet another historic Atlantic "fishery"—the seabird hunt. Early 19th-century fishermen in northern New England outfitted small boats for trips to the barren islands off the coast of Labrador to collect feathers and down from eider ducks as a much preferred substitute for the stiff straw used in pillows and mattresses. These harvests were timed for the moulting periods when the birds were unable to fly. Although not a great many American hunters were involved—many of them normally earned their livelihood by fishing—the millions of birds taken diminished the eider populations to the point where they could no longer sustain a profitable hunt. Canadian law today stringently manages these populations, with only limited recreational takes allowed.

Coastal Atlantic communities will continue to reflect activities of both commercial and recreational fishermen. *Edward J. Pastula, NOAA Fisheries*

A FINAL LOOK AT THE ATLANTIC

These, then, are Atlantic America's fisheries—vital and productive, yet troubled by overfishing, heavy bycatch, habitat degradation, and overcapitalization. Some resources, like cod and herring, support the nation's oldest fisheries, and others, like wreckfish and jellyfish, its newest. Atlantic fisheries provide lobster, shrimp, and other luxury seafoods, along with the humble but lucrative menhaden fish meal. Many Atlantic fisheries stocks are healthy and some are depleted, but most have so many participants that individual profits are greatly diminished. Most of the fisheries resources are fully utilized, and there are few untapped stocks to provide new fishing opportunities in the hundreds of coastal Atlantic communities. These communities are composed of some families that have fished America's waters for many generations, and other families of recent immigrants hoping to carry on fishing skills learned in another world.

Nearly everywhere along the coasts of the Atlantic, Gulf of Mexico, and U.S. Caribbean there is a great divide between the commercial and recreational sectors. Many commercial fishermen live in small towns and work aboard small boats. But some fisheries are conducted from large vessels working out of big cities. And the entire region is awash in recreational boats, beach and pier fishermen, and scuba divers seeking many of the same species targeted by commercial fishermen. For all sectors, it is a changing, complex, and exciting world … and it will flourish.

George Catlin
Detail from *A Crow Village and the Salmon River Mountains*
Paul Mellon Collection
Photograph 1998 © Board of Trustees, National Gallery of Art, Washington

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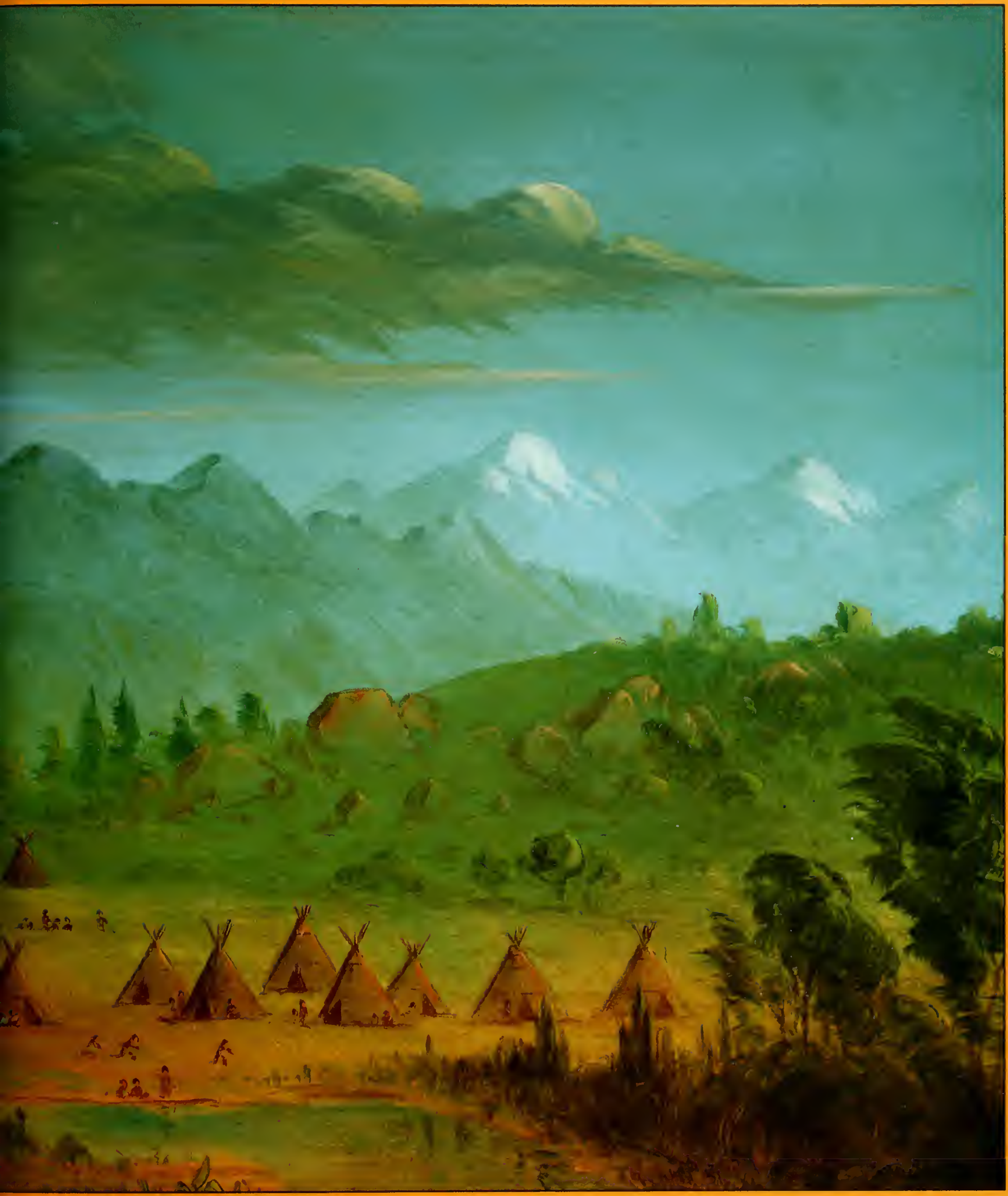
PACIFIC TREASURES



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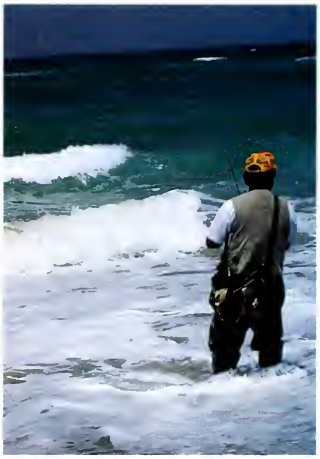
Although they developed later than America's Atlantic fisheries, the nation's Pacific fisheries have long been important to the region's coastal communities. In fact, they contribute greater wealth to the nation today than their Atlantic counterparts. Like the Atlantic section, the information here describes the history, environment, and problems of major Pacific fisheries.

THE PACIFIC REALM

America's fishing domain in the Pacific is geographically greater than in the Atlantic. American vessels fish throughout much of the entire North and South Pacific, along the Pacific Coast from Canada to Mexico, in the Gulf of Alaska and eastern Bering Sea, around Hawaii and the Western Pacific territories, and on the Pacific's high seas. These fisheries are as rich and diverse as their Atlantic counterparts … and yet different. For example, one state—Alaska—alone produces more than 50 percent of the nation's commercial landings in tonnage.

Pacific fishing environments can be characterized as "almost everything"—open ocean and rocky seamounts, bays and lagoons, mud flats and estuarine marshes, rocky and sandy coasts, kelp forests and coral reefs. The continental shelf is comparatively narrow off the Pacific Coast, somewhat wider in the Gulf of Alaska, and extremely wide in the Bering Sea. However, the slope is generally steep everywhere, descending rapidly to abyssal plains, to seamounts, and, in the Western Pacific, to some of the earth's deepest canyons and trenches. It's helpful to look at the physical Pacific realm in terms of three distinct areas fished by U.S. vessels: Alaska, the Pacific Coast, and the Western (Central Western) Pacific islands.



ABOVE: Central California offers some of America's finest surf fishing—and on some of its most beautiful beaches. *William B. Folsom, NOAA Fisheries.* **BELOW:** Massive ice fields are a constant navigational and fishing hazard in the North Pacific crab fishery. © *Karen Ducey*

FACING PAGE: Homeward bound. *Kris Freeman*

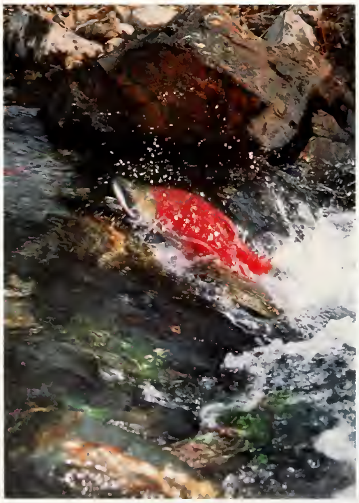
A large crabber makes its way home along the scenic Alaska coast. © *Mandy Merklein*

Alaska itself is nearly surrounded by water—the Gulf of Alaska, Bering and Chukchi Seas, and Arctic Ocean. Its massive coastline is a breathtaking mosaic of rivers and bays, mountains and islands, glaciers and ice fields. Thousands of islands and land spits—some very large—dot the Aleutian Chain and Alaska panhandle. In spite of displaying some of the earth's most profoundly beautiful topography, Alaska's relative isolation and extended cold have been decidedly limiting factors in the state's human population growth, in spite of modern technologies and communications and extraordinary fisheries, timber, oil, and mineral wealth. The howling Aleutian winds, 40-foot Gulf of Alaska waves, and winter ice-locked Bering Sea make Alaska's sea fisheries some of the most perilous in the world.

Alaska is a land of contradictions and surprises. Rain from the moisture-laden Gulf of Alaska is a constant in the state's Southeast. Thus, Southeast Alaska has more snow, ice, and glaciers than the interior, Aleutians, and arctic regions. First-time visitors are also astonished at the dense hemlock and cedar forests along much of the Southeast and South Central areas, and the islands and peninsulas that aren't only hospitable—sometimes almost balmy—during the spring and summer, but afford excellent ports and fishing grounds. And even the more sparsely vegetated Alaskan areas—the vast arctic tundra, stark Bering Sea coastline, and barren Alaska Peninsula—have summer temperatures of 50–60°F that facilitate exploitation of the rich nearshore resources.

From the northernmost Brooks Range to the central Alaska Range, the western Kuskokwims, and the Southeast's Coast Range, immense mountains and wild rivers dominate this sweeping wilderness. Myriad anglers are drawn to the thousands of streams comprising the giant Yukon River system, which drains the Porcupine, Koyukuk, Innoko, and other great rivers into coastal estuaries and inlets and makes possible the incredible runs of salmon and other anadromous fish. There are also many river flows that are too silty, too cold, or too swift to support much fish life, or are inaccessible to all but the most intrepid fishermen.

The wealth of minerals and nutrients in Pacific estuaries combines with unique North Pacific ocean processes to make what is arguably the world's largest and richest fishing grounds. In contrast to the Atlantic ocean processes, where nutrient-rich surface waters sink to the bottom, the subarctic Pacific surface waters don't sink at all. Instead, a freshwater layer floats above the saltier ocean water, flowing out on the eastern side of the California Current, where deep, nutrient-rich water is brought to the surface. This motion is very similar to what occurs in estuaries, and the concentration of nutrients is greater here than in any other oceanic water mass.



LEFT: Thousands of west coast streams are home to returning sockeye and other salmon. © *Brandon D. Cole.* **BELOW:** Nutrients from estuaries like Coos Bay, Oregon, help sustain coastal fisheries resources. *U.S. Fish and Wildlife Service*

Symbols of the Pacific Northwest: the vast Columbia River Basin and its migrating salmon. *Marvina Munch, U.S. Fish & Wildlife Service.* **INSET:** A black-crowned night heron eyes an easy lunch in the bait tank aboard a San Diego charter boat. *William B. Folsom, NOAA Fisheries*

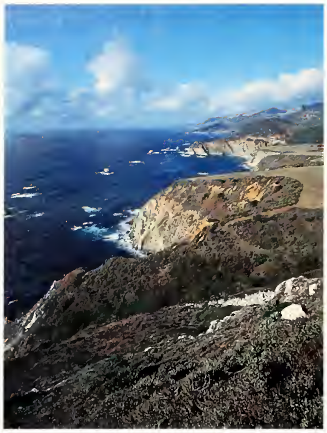
In the Pacific Northwest, the drift of ocean currents over the continental shelf is toward the north through the winter, but reverses during the spring. The timing of this shift and the strength of the coastal current vary from year to year, and periods of the relatively sudden warming known as El Niño can result in enormous shifts, with major consequences for fisheries. The distribution and abundance of many migratory species—such as herring, salmon, anchovy, and hake—are believed to be related to such changes. Farther offshore, a tongue of warm water brings schools of albacore and other large pelagics north during the summer, where they become available to Pacific Coast fishermen.

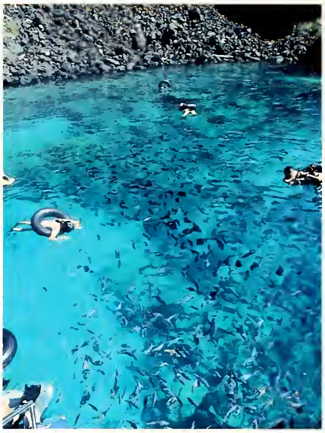
At least from the fisheries perspective, the defining feature of the Pacific Northwest—Washington, Oregon, California, and Idaho (because of its importance to salmon production)—is the Columbia River Basin. This extraordinary network of thundering rivers, placid streams, and coldwater lakes lies between the Cascade and Rocky Mountains and produces a tremendous volume of water from rainfall and snowmelt. The river has been tamed, however, by a vast network of dams designed to provide cheap electricity, flood control, irrigation water, and water-borne transport for crops. The inshore features—Puget Sound and such bays or estuaries as Grays Harbor and Willapa Bay in Washington; Tillamook, Newport, and Yaquina Bays in Oregon; and California's San Francisco Bay—are major contributors to the area's rich fisheries resources. These nearshore embayments are tied to some of the nation's greatest river systems—Columbia, Snake, Rogue, Sacramento, and Klamath.

California's rich aquatic resources, on the other hand, aren't primarily attributable to rivers or other features of the land mass. The state has a narrow continental shelf, averaging only five miles off its southern tip, a characteristic often associated with low productivity. But California has two outstanding ocean features that favor fisheries productivity. The first is the California Current, the eastern limb of the large, clockwise circulation pattern in the North Pacific. This current, which has lower temperatures and salinity and higher nutrient–salt content than is usual for temperate latitudes, transports a galaxy of plankton southward, enriching waters along its entire path. The second feature is a strong upwelling, the process by which prevailing winds push the upper layer of water offshore, to be replaced by deeper, colder water rich in nutrient salts. Marine plant life thrives in this cold surface water and, in turn, supports an intensely diverse food web.

This west coast cornucopia has led to several Pacific areas' being designated as national marine sanctuaries, administered by the National Oceanic and Atmospheric Administration (NOAA). Sanctuary boundaries offer protection from uncontrolled industrial development, while still permitting fishing and boating activities in most areas. There are two sanctuaries off Washington (the Olympic Coast and the Northwest Straits) and three off California (Monterey Bay, Channel Islands, and Gulf of the Farallones). Fagatele Bay, in American Samoa, is also a sanctuary, and there is a Humpback Whale Sanctuary in the Hawaiian Islands.

The Central and Western Pacific have entirely different habitats and ocean processes. Recent satellite observations have shown that ocean currents in this region are more complex and variable than previously appreciated. Basinwide circulation in each hemisphere is locally altered by both winds and the presence of numerous islands and seamounts that block, divert, or fragment the major currents. There are no continental shelves at the oceanic islands of the region, and water depths plunge rapidly away from shore on island





TOP LEFT: California's magnificent Big Sur is part of the immense Monterey Bay National Marine Sanctuary. © *Kip Evans, Kip Evans Photography.* **TOP RIGHT:** Hawaii's crystalline waters beckon reef fish watchers as well as harvesters. © *William B. Folsom Photography, Inc.* **BOTTOM:** American Samoa's fisheries wealth comes not from its beautiful nearshore area, but from vast oceanic tuna stocks. © *Bonnie J. Ponwith*

slopes. There are few fishing banks, and those present are small relative to the major fishing banks of North America.

The 20 islands of the Hawaiian chain, formed by volcanic action, lie in a 1,600-mile arch and rise steeply from a sea floor that averages 18,000 feet deep. The center of the island chain is within the warm, salty North Pacific Central waters. These waters are bounded to the north by a cooler, less salty subtropical front, and to the south by the warmer, less salty North Pacific equatorial waters. The southeastern end of the main Hawaiian Islands is in the west-flowing extension of the California Current, and the other main islands are influenced by branches of that current that flow northwestward. In the summer, especially, the entire system sets up a complex pattern of eddies and fronts. There are few fishing banks, and most of the fisheries catch comes from distant-water tuna and swordfish fleets. A respectable amount of fish, though, is taken quite close to shore, more as a matter of convenience than great nearshore productivity. The most fertile fishing grounds are a few miles northwest of Honolulu.

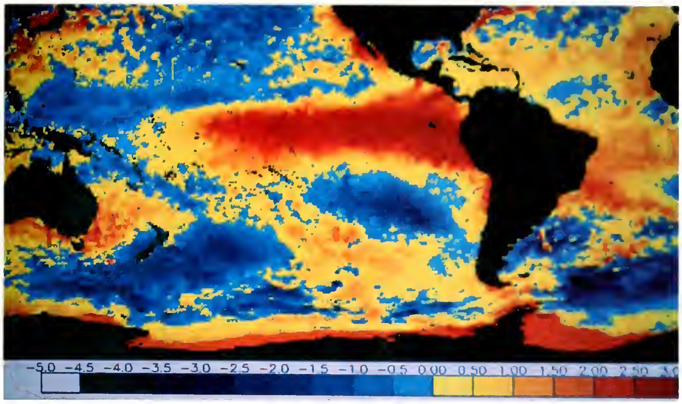
The seven islands that comprise American Samoa are also primarily volcanic in origin (two are tiny coral atolls). The main islands rise abruptly from the sea in a series of ridges, and Tutuila, the largest, offers an immense drowned valley, Pago Pago Harbor, that is large and deep enough to accommodate vessels of any size. Pago Pago is thus the home base for the territory's large fleet of tuna purse seiners and longliners. Narrow coral reefs encircle the islands, bathed by the waters of the warm, sluggish South Equatorial Current system. The islands' coastal reef fish population, hundreds of colorful species, is part of the vast marine fauna centered around the East Indies.

Guam is the southernmost and largest of the islands in the Mariana Island Archipelago. The Commonwealth of the Northern Mariana Islands consists of 14 islands, the largest of which are Saipan, Rota, and Tinian. Although offering good offshore recreational fishing to tourists, principal inshore fisheries are very small. Other than the very important tuna fisheries, American Samoa, Guam, and the Northern Marianas have no large commercial offshore fisheries.

THE SHIFTING ENVIRONMENT: EL NIÑO

Atlantic Coast fishermen often dismiss the infamous "El Niño" as having a negligible effect on their own catches, although the heavier-than-normal rainfalls alone should suggest that isn't true. But there is probably not a fishermen in the Pacific who would make the same claim … with good reason. Once confined to the lofty jargon of oceanography professors, "El Niño" today rolls off the tongues even of kindergartners; it is the culprit of choice for everything from hurricanes to heatstroke. In contrast to earlier years, when climatologists sniffed at the phenomenon as comparatively unimportant, today El Niño is widely believed to drive weather patterns for most of the planet. It has been called this century's biggest weather event, second only to seasonal weather patterns in influencing the world's climate.

El Niño means "the child" in Spanish, named in honor of the Christ child by Peruvian fishermen who long ago noticed that this ocean warming along their coast tended to occur around Christmas. The event is really just one part of the Eastern Tropical Pacific's "El Niño–Southern Oscillation," a naturally occurring climate cycle alternating above-average sea-surface temperatures in El Niño years with cooler "La Niña" years. El Niños spawn hurricanes,



TRADEWINDS
KINGFISHER
DEPOE BAY

ABOVE: A NOAA satellite image shows warmed Pacific water mass shifts that presage fish stock changes. *Courtesy National Environmental Satellite, Data, and Information Service, NOAA.* **RIGHT:** An El Niño can spell an alarming drop-off of business to both charter boats and commercial fleets. © *Brenda Matthiesen/Unicorn Stock Photos*

monsoons, droughts, tropical storms, and a host of other severe weather conditions. Because of their immense influence on so much of the entire world's human activity—food and timber production (including fishing), transportation, communications, construction—NOAA has established a vast array of buoys that measure minute changes in winds, currents, and water temperatures, to help predict the shifts and severity of these phenomena.

If recent El Niños have captured everyone's attention, it was the phenomenon's periodic crippling of some Eastern Pacific fisheries that first captured scientists' attention. Warm El Niño years have generally been perceived as disastrous to fisheries, killing immense numbers of anchovies and other small forage fish that sustain South American fish meal industries. They also cause geographic shifts of tuna and other predators heavily fished by South American nations. As west coast fishermen are discovering, the El Niño news is mixed. Squid can totally vanish from Pacific harvests, but the dislocation of tuna and some other species north into cooler waters means bountiful U.S. harvests. At the same time, some fishermen of salmon and Pacific whiting may watch in dismay as their targets, too, migrate north into cooler waters, sometimes to the great joy of Canadian fishermen. And conversely, one Canadian salmon run—Fraser River sockeye—has changed migratory patterns in recent warmer years, staying in Canadian waters and denying American fishermen their historic share of the catch.

A very large El Niño rocked west coast fisheries in 1982–83, and during the 1997–98 El Niño NOAA recorded temperatures 3–5 F or more above normal along the California coast. This great environmental change almost certainly signals significant disruptions in the availability of species to fishermen. Fishermen have recently requested federal disaster assistance for reduced catches, claiming that the El Niño constitutes a single naturally occurring event that entitles assistance under Small Business Administration and other disaster relief programs. El Niños undeniably have a detrimental impact on some fisheries, and the effect is even more dramatic when the scarcity of forage fish also affects millions of seabirds and marine mammals, causing die-offs and

BELOW: El Niño's warmer seas often bring more pelagics—like mahi mahi, tuna, and swordfish—within reach of U.S. fishermen. *Dennis M. Weidner, NOAA Fisheries.* **RIGHT:** Some rockfish species highly valued along the west coast may be displaced by warming sea temperatures. *Marty Golden, NOAA Fisheries*

Deep-blue offshore waters don't reveal the El Niño warming that threatens fishermen's income. *© Allen M. Shimada*

mass migrations. Claims for restitution have until recently been unsuccessful where the damage is believed to result from normal climatic cycles, or when it grows difficult to distinguish El Niños from the continuous heating that may signal global warming. However, some assistance has been given for natural disasters in the Gulf of Mexico and in Alaska.

FROM THE EARLIEST DAYS …

Salmon, one of today's most controversial west coast fisheries, at one time completely defined Pacific Coast fishing. The region's commercial fisheries began in the mid-18th century, as Russian fur hunters and traders sailing south from the Aleutians found the abundant spring and summer salmon a rich food source that could be salt-cured for winter food. Consumption was primarily local, and it wasn't until the 1820s that British-American traders, particularly the Hudson Bay Company, contracted with Northwest tribes for salmon as an export product to Alaska's Russian colonies, to England, and to provision whaling ships on their Hawaii stopovers.

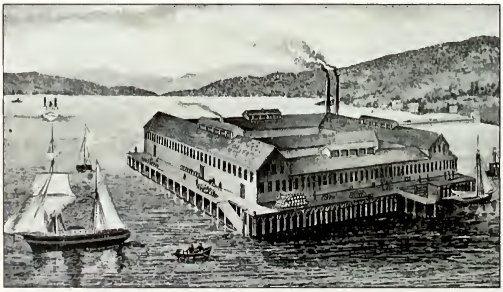
The 1849 California gold rush, with its hordes of immigrants to the region, produced a great demand for central California salmon. The first salmon cannery was built in Sacramento in 1864, followed quickly by many more along the Columbia River. When Alaska was purchased from Russia in 1867, canneries sprouted up there as well. By the end of the century, Alaska accounted for 40 percent of the west coast salmon production, centered in Bristol Bay and Kodiak Island.

Fishing was seasonal, though, with both fishermen and cannery workers migrating north each year, a largely immigrant work force of southern Europeans, Scandinavians, Chinese, and Native Americans. Commercial fishermen relied heavily then (as now) on gillnets operated from small boats, but traps, fishing wheels, and horse-towed beach seines were also widely used.

If the Pacific Northwest and Alaska offered good harbors that favored fisheries development, California had the opposite situation: fisheries development was limited by the scarcity of natural harbors. The state's commercial fishing fleets have largely been restricted to Eureka, San Francisco, Monterey, Morro Bay, Santa Barbara, Ventura, San Pedro, and San Diego. Recreational fishing boats, of course, don't require deepwater ports or industrial wharves; hence, the remarkable growth of California's recreational fleet in shallow bays everywhere.

Although relatively few in number, indigenous Pacific people everywhere exploited the nearshore resources. Alaska, and the Western Pacific territories, in particular (and the Columbia River Basin and Northern California, to a lesser extent), still have substantial native populations whose historic occupancy of coastal lands gives them, they believe, undisputed and perpetual rights to traditionally harvested resources, including fish and mammals. The courts have agreed, sometimes under bitter controversy, as when the United States sued Washington and Oregon on behalf of some Pacific Coast tribes to reserve fishing rights awarded under 19th-century treaties. In other instances, state and federal management plans have accommodated historic fishing rights through more amiable means.

LEFT: This early salmon cannery was one of many that supplied the 19th-century immigrant labor force. *From a photograph (photographer unknown), The Fisheries and Fishery Industries of the United States, NOAA Fisheries.* **RIGHT:** Turn-of-the-century beach seiners at Seattle's Sand Island land a good haul of Columbia River salmon. *Special Collections, University of Washington Libraries, photo by Woodfield, negative #UW 5722*



LEFT: San Francisco relied on small sailing dories in 1880 to take groundfish, herring, and salmon. *Eureka Federal Savings North Branch Museum, San Francisco; courtesy of National Fisherman.* **ABOVE:** An early 20th-century Northwest tribal elder cures salmon fillets on a smoking frame. *Courtesy of Pacific Fishing magazine*

The sheer number of involved cultures and tribes—Eskimos, Aleuts, Inuit, Inuivalit, Tlingit, Chilkat, Haida, and others in Alaska; Nez Perce, Umatilla, Warm Springs, Yakama, Klamath, and 24 other tribes in the Pacific Northwest; Yurok, Hoopa, and other tribes in Northern California; and Polynesian and Micronesian cultures of Hawaii, American Samoa, Guam, and the Northern Mariana Islands—guarantees that not all rights are yet perceived as restored, or shares as adequately assigned. (Most recently, arguments for historic allocations have spilled over—successfully—as demands for restoration of rights to hunt whales, seals, and other rebuilt marine mammal stocks. And these demands may well be the source of great conflict with the many Americans opposed to harvesting these protected species.)

THE FISHERIES

If New England's fisheries inspired such classic tales as Melville's *Moby Dick*, newer popular fiction continues to be inspired by Pacific fishermen. Perhaps most famous was *Cannery Row*, John Steinbeck's haunting depiction of the Depression-era Monterey sardine fishery (Steinbeck's fascination with the sea also led to *The Sea of Cortéz*, his memoirs of recreational fishing in Mexico's Gulf of California). There have been many other notables: Jack London's recounting of his early San Francisco childhood as an "oyster pirate"; Martin Crúz Smith's *Polar Star;* and, most recently, David Guterson's *Snow Falling on Cedars.* There is also a rich folklore of whaling, sealing, and fishing by indigenous people, but these stories are often relegated to the children's library section or are available only in regional book stores.

Aside from early whaling and sealing, however, large Pacific fisheries are of recent origin. For most of its history, fishing as an occupation was far behind the West's mining, logging, and, for "the lower 48," farming. In Alaska and the Northwest, especially, the decline of the timber industry and mineral extraction forced many unemployed workers to turn toward the sea for both large-scale and subsistence fishing. One direct result has been the growth of seafood processing in Alaska's Southeast—Ketchikan, Craig, Petersburg, Wrangell, Sitka, and Juneau, its capital.

Although younger and conducted in different ways, Pacific fisheries are just as valuable as their Atlantic counterparts. The "mix" of cultures plying the Pacific trade is also notably different: where "old Yankee," Cajun, Slavic, Spanish, Portuguese, and Italian surnames dominate the Atlantic, Alaska and the Northwest are stews flavored with German, French, and Russian heritage and spiced with a

The radiant Pacific inspires stirring sea tales, but its rougher side can claim fishermen's lives. © *Mandy Merklein*

LEFT: Ketchikan, shown here in the 1950s, has remained an important Southeast Alaska fishing port. *Scientific Publications Unit, NOAA Fisheries.* **ABOVE:** Many Pacific fishermen, like this Alaska shrimp trapper, show a Scandinavian ancestry. © *Kris Freeman*

strong Native American presence. Some fisheries in the early 1900s were developed by Chinese and Japanese immigrants to California. Sadly, many vessels belonging to descendants of the Japanese immigrants were later confiscated—without compensation—when the owners were forced into World War II relocation camps, and were never returned.

There is also a strong Scandinavian influence—especially from Norwegians who dominated 19th- and early 20th-century North Pacific halibut, groundfish, and herring fisheries, much the same as they had done in Europe. Their legacy is still evident in both the seafood restaurant and the fishing trades. If Brancaleones and Testaverdes give Gloucester a unique Italian flavor, and Thibodeauxs and Chauvins add Cajun spice to New Orleans, the tone of many Washington and Alaska ports is set by the Pedersons and Nansens. Indeed, the entire nation bears witness to this presence in the name of the original overarching modern fisheries statute, named after the estimable Senator Warren Magnuson.

With greater frequency than in the East, the ethnic character of many Pacific ports has blurred as the vast underexploited riches of the North Pacific beckoned harvesters of all stripes and dialects. The burgeoning groundfish harvests of the North Pacific have seen waves of Asians and Hispanics in shoreside processing plants, while the west coast groundfish industry has seen substantial investment by Vietnamese immigrants. Even the distant Western Pacific fisheries have seen culture shifts as Vietnamese and Old Yankee swordfish longliners and Italian- and Portuguese-American tuna purse seiners fish in waters formerly dominated by Americans of Polynesian or Asian heritage.

Like its Atlantic counterpart, development of the Pacific fishing industry has led to heavy competition and increasing searches for new target species. Some vessels now range over vast ocean stretches, longlining for sablefish off Northern California or setting traps for crabs far out in the Bering Sea.

LEFT: Seattle's Fisherman's Port is home to a growing number of boats that participate in more than one fishery. *William B. Folsom, NOAA Fisheries.* **RIGHT:** Nets coming aboard a trawler in Bristol Bay, Alaska, are checked for prohibited species–crabs, salmon, and halibut. © *Allen M. Shimada*

LEFT: Pacific trawls bring up a mixed bag of fish and invertebrates, many of them destined for discarding. © *Allen M. Shimada.* **ABOVE:** Bycatch is a problem affecting both large vessels and these more modest ones docked in Bellingham, Washington. *William B. Folsom, NOAA Fisheries.*

The spreading of one's effort into more than one fishery can have an impact on both markets and fisheries management. Many of the more moderate-size boats in the groundfish fishery, especially, see this interdependence. Although groundfish is generally considered a more stable source of income than other resources, prices are frequently more modest. As a result, abundance and prices in the salmon, shrimp, tuna, and crab fisheries play an important role in determining the level of fishing effort directed toward almost all species. Managers have learned that they must somehow develop strategies that recognize the potential impact of one's fishery regulations on other fleets.

One such strategy, long in place, and not without consequent difficulties, was developed to cope with the bycatch of certain traditionally important species—halibut, crab, salmon, and herring—in North Pacific groundfish trawls. These animals often show up dead or dying, and in large numbers, in trawl nets. However, regulations don't allow trawl fishermen to sell or trade those traditional species, except under some very special conditions. In fact, strict limits are set on the amount of bycatch that can be taken by groundfish fishermen before their fishery closes in a particular area. This bycatch penalizes both groups of fishermen: those targeting crab, halibut, salmon, or herring—who have to endure smaller quotas that have been adjusted for bycatch—and the groundfish harvesters who take these species as bycatch, and may face early closures due to a bycatch limit being exhausted. This can be particularly true for trawlers targeting the very abundant Bering Sea flatfish, but who also capture halibut and crab as the trawls move along the bottom. These flatfish fisheries often close down early, as does trawling for Pacific cod, leaving uncaught quotas worth millions of dollars and many unhappy fishermen.

There is no paucity of bycatch issues in Pacific fisheries, but west coast fishermen have been at the forefront in pushing to reduce bycatch and discarding of untargeted fish, especially in Alaska. Some bycatch activism has resulted from a belief that strong conservationist anger at the take of dolphins in California tuna purse seines was at least partly responsible for the entire industry's relocating across the globe to Samoa. Most fishermen have other motives: a genuine wish to avoid taking marine mammals or fishery resources that "belong" to other fisheries; a real desire to avoid waste and ensure healthy ecosystems; and a growing belief that fisheries resources are, after all, finite.

The industry has, in fact, proposed some very innovative bycatch reduction strategies based on giving vessels incentives (or disincentives) to avoid species and sizes of groundfish they would have to discard. One proposal, for example, would provide for some type of punitive damage, in the form of reduced allocations, for vessels with high bycatch rates, while those with lower rates would receive extra shares. To date, however, such proposals have been found to inadequately address constitutional guarantees of due process. Without a system of appeals and restitution, penalties or rewards unfairly or erroneously assessed could mean financial losses or gains worth millions of dollars. Other systems may offer greater promise, such as individual vessel bycatch quotas where the overall bycatch limit for the entire fleet is allocated to individual vessels. Then, when vessel captains choose to fish cleanly, they reap the reward of a longer fishery, whereas "dirty" fishermen who take more bycatch knock only themselves out of the fishery.

There are other obstacles to bycatch control. The amount of scientific information is sometimes inadequate, especially on the magnitude of discards and unobserved mortality, animals' ability to escape fishing gear, the economic and social impacts of bycatch, the effects of regulations on target and nontarget species, and the ecological consequences of both discarding and fully utilizing catches. Too, many fishing operations are financially marginal and unable to invest in more selective gear or fishing practices, or they may simply be unaware of innovations in other countries or other fisheries. Maintaining a year-round fishery, as many processors want, has led to very small trip limits, with associated heavy bycatch that forces

LEFT: Fish in the giant North Pacific pollock hauls are sometimes discarded because they're too small for processing. © *Mandy Merklein.* **TOP RIGHT:** Schools of yellowstripe snapper, a reef species, help make up the Hawaiian bottomfish catch. © *Brandon D. Cole.* **BOTTOM RIGHT:** Spills from massive tankers, like this one in Prince William Sound, are a concern of Alaska fishermen. © *William B. Folsom Photography, Inc.*

fishery managers to set quotas even lower. And there may be unfortunate interactions between fisheries, as when vessels that have reached their target fishery's bycatch "cap" often shift operations to other areas and target species, thereby altering bycatch patterns in an increasingly familiar domino effect. Time or area closures, gear restrictions, and other measures can have similar impacts, and sometimes what solves one bycatch problem creates another.

In the Western Pacific, unique fisheries interactions have also surfaced. There is a suspicion that significant mortalities of protected sea turtles may be occurring among the international fleets in the Pacific. The Hawaii-based U.S. longline fisheries for tuna and swordfish contribute to this mortality. Area closures have helped prevent interactions with protected Hawaiian monk seals, but gear encounters with sea turtles are more problematic because both the fleets and the animals roam over a vast stretch of the ocean.

If bycatch issues constitute a problem in some Pacific fisheries, the region has to contend with a plethora of headaches also prevalent in the Atlantic and Gulf of Mexico: habitat loss and degradation, overfishing, overcapitalization, and intense competition. Pacific fisheries are distinct in important ways, however, such as the strong presence of indigenous groups staking historic claims to fishing rights, and a generally higher level of formal education among fishermen. And, unlike the Atlantic, overfishing hasn't yet emerged as the major difficulty—most resources, though heavily utilized, appear to be in better health … for now.

In 1998, estimates were that only about 13 percent of Pacific stocks that had been assessed were overutilized, as compared with 40 percent of Atlantic stocks. About 48 percent were fully utilized in the Pacific, compared with 24 percent in the Atlantic. And a full 27 percent of Pacific stocks were considered underutilized, compared with only 7 percent in the Atlantic. (The status was unknown for about 12 percent of Pacific stocks, and 29 percent of Atlantic). And in the nation's largest fisheries, those in Alaska, only one species, Bering Sea Tanner crab, was identified as overfished as of late 1998.

Groundfish

The U.S. fisheries for Pacific groundfish (also commonly known as bottomfish)—primarily Alaska pollock, Pacific cod, whiting, sablefish, flounders, Pacific ocean perch, halibut, and rockfish—are immensely valuable. Worth less than $150 million in 1987, they now bring commercial fishermen $500–$600 million a year. Alaska's Dutch Harbor is by far the American port with the greatest volume—as well as value—of landings, but pollock, especially, has also made Alaska's Kodiak, Ketchikan, Akutan, King Cove, and Cold Bay among the nation's leading fisheries ports. Ketchikan, Petersburg, Sitka, and Seward are also important to other Alaska fleets, especially those targeting Pacific cod, sablefish, and rockfish.

Groundfish problems are similar to those of the Atlantic Coast and Gulf of Mexico: who gets what fish, and when. In common with other U.S. regions, issues are overcapitalization, declining

Not all Pacific groundfish are found offshore—joyful anglers on a Kodiak dock harvest a few rockfish for dinner. *Charlie Ess, NOAA Fisheries*

stocks, bycatch, and specific management measures. If the nature of issues is similar, there are significant differences in their scope, causes, and outcomes, reflecting a great diversity and availability of target species and habitats, size and type of vessels (and gear), processing locales, management regimes, interactions with protected or "prohibited" species, and a host of other considerations. Commonalities are few, however, beside the rather loose definition wherein the involved species are generally found on or near the ocean bottom in mixed assemblages. But even here, there is confusion: in both the continental states and the Western Pacific, fishermen refer to species that live among reefs as both reef fish and bottomfish. And in at least one case—and a rather big one, at that—the dominant species (Alaska, or walleye, pollock) is usually high enough off the bottom to be taken in massive mid-water trawls.

It's helpful to look at these fisheries in somewhat smaller units of Alaska groundfish, Pacific Coast groundfish, and Western Pacific groundfish. Because Pacific halibut is so different from the other groundfish species, it's covered separately.

Alaska Groundfish

Groundfish off Alaska is the most abundant of all American fisheries resources, but astonishingly, except for some very early Pacific cod fisheries, the resource was largely unfished by Americans prior to 1977. The passage of the original Fishery Conservation and Management Act in 1976 led directly to today's massive domestic groundfish fleet, the nation's largest in both volume and value.

Alaska's groundfish assemblage is most commonly thought of in terms of Bering Sea–Aleutian Islands (familiarly known as BSAI) stocks, and Gulf of Alaska stocks, each with unique mixes and stocks, and each with distinct management regimes. Although with less volume and value than BSAI fisheries, Gulf of Alaska catches are also enormously valuable. As with BSAI catches, though, Gulf groundfish harvests are intentionally kept lower than their potential in order to reduce bycatch—in this case, primarily halibut. Where pollock dominates the BSAI, sablefish is the most valuable Gulf species, bringing in about half the groundfish revenue, with pollock, Pacific cod, and flatfish making up the majority of the remaining Gulf groundfish revenue.

Alaska's Kodiak has become one of the nation's top fishing ports. Kodiak Island is part of the Aleutian Islands that separate the Gulf of Alaska from the Bering Sea. *Charlie Ess, NOAA Fisheries*

Most of the groundfish catch is in bottom trawls or, in the case of pollock, in mid-water trawls, and some of these are gargantuan nets capable of taking many thousands of pounds of fish in a single haul. These larger nets, especially, are deployed from giant freezer-trawler ships with cavernous holds for factory-line processing of the freshly caught fish. And these vessels may also take on fish over the side from smaller vessels not wishing to transport their product to shoreside plants. There continue to be fractious "inshore-offshore" disputes between these processing sectors, each side claiming the greater economic contribution in hopes of garnering a larger slice of the groundfish pie. Wisdom-of-Solomon allocation decisions must be negotiated every few years, but with much of the fleet—as well as much of the shoreside processing sector—in tangled foreign ownership, it is nearly impossible to get a clear accounting of who owns what.

Groundfish vessels range from the giant factory ships several hundred feet long—which carry hundreds of workers to process the catch around the clock and which often have associated, smaller catch vessels—to rather small trawlers of 70 feet or so, manned by crews of five to ten people. In between are trawlers of about 150–200 feet. One of the continuing issues surrounding most of the fleet, though, is the extent to which prohibited species are taken—vessels are required to have trained, independent observers on board to record catches of salmon, halibut, herring, and crab. Factory ships all carry observers, but mid-size vessels carry them only some of the time, in accordance with a predetermined schedule, and the smallest boats generally don't carry any observers at all.

This observer requirement was implemented decades ago to ensure that the United States had reliable information on fish taken by foreign vessels fishing in the North Pacific. Comprehensive observer requirements were implemented in the domestic groundfish fisheries beginning in 1990, just as they became fully Americanized. To this day, observers are really the only feasible way to measure the catch—and, especially, the bycatch. The relationship between observers and vessel owners/operators has sometimes been uneasy. Observers have been intimidated, physically and verbally abused, and refused payment for the arduous and dangerous task they perform. There is some hope that technological innovations—surveillance cameras or counting devices—may reduce the reliance on observers, but nothing of this nature has surfaced to date, and if it does, the industry will need to spend many years testing these innovations.

The financing of North Pacific observer programs is also problematic. Since 1990, observers trained and certified by the federal government have been hired and deployed under individual contracts with several small private firms that collect fees from the fleet. This isn't necessarily the case for the many other U.S. observer programs, especially where the concern is for bycatch of protected species; these are often government-funded. In Alaska, these "vessel pays" programs can be especially onerous for some small-boat owners. There are continuing questions about whether individual

FAR LEFT: Crews on North Pacific groundfish vessels generally enjoy good wages, but the life is hard and dangerous. © *Mandy Merklein.* **NEAR LEFT:** Many pollock are processed on board factory ships, but onshore plants also handle large amounts of the catch. *Scientific Publications Unit, NOAA Fisheries.* **BELOW:** In this winter fishery, crab is unloaded onto shoreside processing ships in St. Paul, Alaska. © *Karen Ducey*

LEFT: Observers calculate the volume of a groundfish haul aboard a North Pacific trawler. © *Mandy Merklein.* **ABOVE:** The immense pollock harvest is used primarily for surimi in artificial crab, lobster, and other premium seafood. © *William B. Folsom Photography, Inc.*

Alaska vessel owners should pay for their own observers, or whether an overall fee should be collected from everyone, from which observer costs would be paid.

Another thorny issue concerns the impact of these giant harvests on Steller sea lions, which must compete with the trawlers for the pollock and other fish species on which they depend. It has been suggested that pollock harvests are an important factor in the declining sea lion populations (the two stocks are now listed under the Endangered Species Act). In response, managers and the industry have implemented measures to reduce fisheries' impacts—most important, closing waters from 10 to 20 nautical miles around sea lion islands to minimize vessels' disturbance of these rookeries.

The Bering Sea and Aleutian Islands portion of the groundfish take, which brings fishermen about $300 million each year, is larger than the Gulf of Alaska's $100-million catch. Dominant species are pollock, Pacific cod, and yellowfin sole, with pollock the most valuable because of its sheer tonnage. Pollock, in fact, constitutes the largest catch of any single species in the nation's Exclusive Economic Zone, but the resource is actually composed of three distinct stocks, all close to full utilization, from the eastern Bering Sea, Aleutian Basin, and Aleutian Islands.

In the late 1980s, foreign fleets that were displaced from the U.S. fishing zone by the growing American groundfish fishery moved into the international area in the central Bering Sea, the so-called "Donut Hole." The Donut Hole lies just outside the 200-mile jurisdictions of both Russia and the United States. Foreign fleets conducted heavy and uncontrolled fisheries for pollock in that area, and also slipped into the surrounding U.S. waters under the cover of night or heavy weather. Large tonnages of pollock were taken in the Donut Hole into the early 1990s, and the stock became so depleted that foreign fishermen agreed to abide by a moratorium on further fisheries there, beginning in 1993. Since

LEFT: Pollock catches, such as this haul off Alaska, are strictly monitored to prevent overfishing. © *Brad Matsen.* **RIGHT:** An American fishing vessel delivers fish to a Soviet stern trawler in 1983, the heyday of joint fishing ventures. *Scientific Publications Unit, NOAA Fisheries*

ABOVE: In recent years, Pacific whiting, or hake, have supported an important fishery in the Northwest and Alaska. © *Allen M. Shimada.* **TOP RIGHT:** An outdoor market in Newport Beach, California, offers locally caught sablefish and rockfish. *William B. Folsom, NOAA Fisheries.* **BOTTOM RIGHT:** The aptly named thornyhead is an important component of the Gulf of Alaska longline fishery. © *Allen M. Shimada*

then, international fleets have moved north of the Donut Hole to the region along the boundary between Russia and the United States. Pollock fishing on the Russian side has the potential to reduce the stocks of pollock on the U.S. side because of the fish's migratory patterns across the northern Bering Sea. Both sides are attempting now to establish a more cooperative management regime that will ensure that these "transboundary" pollock stocks remain sustainable in the future.

Although BSAI pollock stocks are quite variable among years, the catches have remained stable, while Pacific cod catches have seen more ups and downs. This fishery started in the 1860s with hook-and-line gear in the Sea of Okhotsk, expanding to the Shumagin Islands when Alaska became a U.S. territory. Until recently, this "P-cod" resource wasn't greatly valued, probably accounting for its somewhat underutilized status today. Nevertheless, it brings fishermen more than $100 million a year. Like some other North Pacific groundfish fisheries, bycatch caps for halibut and crab have closed the cod harvests early some years, leaving quota on the table.

Flatfish, though, are generally considered underutilized. With the exception of Greenland turbot, they're quite abundant. Their generally healthy stock condition stems from their bottom-dwelling lifestyle, where they mingle with halibut and crab. Management generally curbs the flatfish harvests to ensure that excessive bycatch of the higher-valued halibut and crab remains low. The most abundant of these species are rock sole, yellowfin sole, and flathead sole. Arrowtooth flounder is particularly abundant in the Gulf of Alaska, but seldom desired by fishermen because the flesh becomes mushy when cooked. Until that processing problem can be overcome, arrowtooth stocks will continue relatively unfished.

Other species also support this enormously valuable groundfish complex. Sablefish (or blackcod) is among the most prized, taken with longlines and trawls. Sablefish is abundant in the Gulf of Alaska, although it appears to be declining due to a lack of strong recruitment.

Some Alaska groundfish resources, such as Atka mackerel, aren't very familiar to the public. This species supported a large foreign fishery through the mid-1980s. Management became quite conservative because of uncertainty about the size of

Alaska is dotted with Native American fishing communities, like Kotzebue, on the edge of the Chukchi Sea. *Scientific Publications Unit, NOAA Fisheries*

the stock, and the fishery subsequently all but disappeared. Recent evidence that Atka mackerel is much more abundant than previously believed has helped fuel a new fishery in the Aleutians, although the species is also harvested in the Gulf of Alaska.

Rockfish, especially Pacific Ocean perch, have long been a staple of the groundfish catches, sometimes bringing fishermen more than $40 million a year. Taken by longlines as well as in trawls, BSAI harvests of several species have dropped sharply in recent years as a result of the heavy foreign fishing on these long-lived fish in the 1960s. Rockfish species living on the Gulf of Alaska slope—Pacific Ocean perch, shortraker and rougheye rockfish, thornyhead and northern rockfish—are all slow-growing, long-lived fish whose stocks were formerly overfished and are only now showing signs of rebounding. Other species, such as yelloweye rockfish, inhabit the rocky pelagic shelf off Alaska. The status of these stocks is unknown because the traditional trawl surveys used to assess groundfish don't work on this rough terrain, and other methods of investigation, such as manned submersibles, are just beginning.

Still other users of groundfish resources are Alaska's indigenous people. For thousands of years, Native Americans have fished the region's coastal waters for salmon and other species, but their permanent rights to harvest groundfish have only recently been recognized in state and federal management plans. Nowhere is this more prominent than Alaska's Community Development Quota system, which began in late 1992 to allocate a portion of the Bering Sea groundfish fisheries to economically disadvantaged communities in Western Alaska and the Aleutian Islands. Six groups representing 56 villages have developed programs to turn these allocations into benefits for their communities.

Pacific Coast Groundfish

Although considerably smaller than Alaska's landings, the groundfish catches off Washington, Oregon, and California are still quite valuable, bringing commercial fishermen about $80 million a year. Some towns have been fishing for rockfish, sablefish (also known as black cod), and flatfish for more than 100 years. The dory fleet in Newport Beach, California, has even been awarded status as a historic industry, and beachgoers can still buy rockfish and sablefish from dorymen who fish much as their predecessors did at the end of the 19th century. Commercial rockfish landings occur everywhere along the Washington coast; in Newport, Oregon; and Eureka, California. But rockfish, sablefish, sole, and ling cod are also taken coastwide in California. Today, this fishery includes such diverse elements as catcher–processors taking Pacific whiting in mid-water trawls, trap and longline vessels harvesting sablefish at depths of up to 4,000 feet, and nearshore fishermen seeking live capture of rockfish.

In common with Alaska, Pacific Coast fleets target many species and habitats, using a wide variety of gear. One readily distinguishing characteristic, though, is the much greater Pacific Coast recreational fishery for these resources, which tends to focus on rockfish and ling cod (which are also prime commercial targets). The mix of important Pacific Coast groundfish species in the Northwest is different from the mix in Alaska, too. Pollock is seldom taken, and by far the largest landings are for Pacific whiting, bringing fishermen up to $18 million a year. This burgeoning fishery—heavily centered

Fishing FAMILIES

Jan and Jim Baker, shown here cleaning their catch, run one of the picturesque stands at the historic dory fleet in Newport Beach, California. Jan keeps the accounts and helps sell the colorful rockfish and sablefish her husband Jim catches daily in nearby waters. Pooling their time, skills, and energy, the Bakers represent a kind of family enterprise that's recognizable in many coastal fishing communities. Businesses of this type, where family members have found a way to work side by side, have flourished throughout America for generations. For most American fishermen though, long days—or even weeks—at sea separate family members, making "togetherness" a difficult goal. Additionally, relatively few U.S. harvesters market their catch directly to the public, making family enterprises like the Bakers' less visible here than in many developing countries.

At-the-dock family operations were once widespread in coastal American communities, and even small children could be seen cleaning and sorting the catch. But the modern era has brought change: reflecting an industry beset by a flood of imports and intense competition, many wives and working-age children have reluctantly had to seek outside employment. In some cases, bookkeeping and provisioning have suffered, but perhaps more distressing to families who have fished for generations, there's no one left who knows how—or desires—to continue the family business. Other clans, though, have found ways to expand their operations, and one can often find each son and daughter—or even grown grandchildren—of a fishing family with boats of their own, continuing the proud legacy.

Jan and Jim Baker, Newport Beach, California (William B. Folsom, NOAA Fisheries)

San Francisco's Fisherman's Wharf has served up some of the nation's finest seafood for more than 100 years. © *Allen M. Shimada*

in Oregon ports, and with an at-sea catcher–processor and mothership fleet operating out of Seattle—has undergone allocation friction between inshore and offshore fishing and processing firms that is similar to the battles over Alaska groundfish.

More than 50 rockfish species are found along the Pacific Coast, although most landings are of bocaccio, widow and yellowtail rockfish, thornyheads, and several family members whose colorful names convey their appearance: canary, chilipepper, and shortbelly. Flatfish are an important component of this fishery, too, especially Dover sole, English sole, and petrale sole. In many people's view, these are the finest-tasting flounders in America, and they command a hefty restaurant price. Rounding out the Pacific groundfish stocks is the abundant Pacific cod.

The fishery for rockfish, especially Pacific "red snapper," can be hit particularly hard when El Niño conditions dominate. As with the salmon that migrate south along the California coast each year, the animals' encounter with warmer-than-usual water takes a serious toll on the fish. Recent surveys have found far fewer young fish than in non-El Niño years. This may become a problem for commercial fishermen, but may be less serious for charter boats, which

LEFT: Typical Oregon trawls show a surprising variety of rockfish, the dominant groundfish component. © *Allen M. Shimada.* **RIGHT:** A California Department of Fish and Game biologist checks recreational groundfish catches at a Dana Point dock. *Marty Golden, NOAA Fisheries*

China rockfish, seen here on a rocky outcropping, may now be overfished due to increased "stick fishing." *© Brandon D. Cole*

can often switch to tuna and other species suddenly appearing in newly warmed local waters.

Pacific Coast groundfish are managed under a federal plan, and their status is generally good. Pacific ocean perch, ling cod, and bocaccio may be overfished, but shortbelly rockfish and a few other species may be able to withstand some additional fishing pressure. For most species, though, there isn't enough information to determine their status.

A new wrinkle in the California groundfish fabric has the potential to undermine populations of nearshore rockfish—China rock, vermillion, black-and-yellow, and grass—as well as such other shallow-water fish as cabezon, sheepshead, sculpin, and greenling. "Stick fishing" is a recently developed, legal method for taking the live fish, valuable especially to the west coast's burgeoning Asian restaurants, and has increased the catch of these species to a point where localized depletions are becoming common. The longline-like method uses PVC pipes weighted to lie on the sea floor, with hooks attached to a line running the length of the pipe and the whole apparatus retrievable by means of attached buoys that can be pulled by hand. Several hundred harvesters are involved in this central California fishery, which, because of its simple gear and the high prices paid for the fish (up to $5 per pound), is attracting recreational fishermen and others not formerly considered commercial fishermen. The sheer number of harvesters threatens the viability of many of these slow-growing stocks.

Halibut

Pacific halibut was among the first species of real importance to North Pacific domestic vessels, only slightly behind salmon. Although most of today's halibut comes from the Gulf of Alaska, the resource is actually taken from the Bering Sea to Oregon, and was at first fished primarily in the Puget Sound–Vancouver area. The fishery is old, originating in 1888. The resource currently brings U.S. commercial fishermen more than $85 million a year, and also supports a very active recreational fishery. Following serious overfishing at the turn of the century, Pacific halibut is well managed today through the International Pacific Halibut Commission under a treaty between the United States and Canada. The resource has recovered and is fully utilized, but like most fisheries, annual abundance and distribution of halibut vary, and there is currently a small but steady decline in the population.

Though the halibut fishery has been well managed to sustain resource abundance over time, during the 1980s more and more vessels from Alaska and the west coast crowded into the fishery. This giant fleet, tightly controlled by strict seasonal quotas, caused the fishing season to dwindle from more than 100 days a year to

Wooden schooners like this were the backbone of Alaska's turn-of-the-century halibut fishery. *Scientific Publications Unit, NOAA Fisheries*

ABOVE: Seattle's Fishermen's Memorial is a somber tribute to fishermen who have lost their lives to fierce North Pacific seas. *William B. Folsom, NOAA Fisheries.* **BELOW:** Pacific halibut are gaffed aboard as the longline is retrieved after a successful set. © *Brad Matsen*

semiannual 24–48-hour derbies. These derbies saw long, long lines of fishermen at the processor docks, while fish quality and market prices went down. Many fishermen also went out in dangerous weather rather than miss a short, intense opening—conditions were especially dangerous if the derby happened to coincide with rough weather, resulting in many injuries and deaths.

Since 1995, however, the halibut longline fishery has been managed together with sablefish through individual fishing quotas (IFQs) that permit the fishermen "shareholders" to catch and market the halibut whenever they like. Although fishing is safer now, in spite of the thousands of U.S. vessels licensed for the halibut fishery, and the quality and year-round availability of halibut are much better, some fishermen who didn't qualify for IFQs (and are thus compelled to buy or lease shares from someone else if they wish to take halibut and sablefish) dislike this regime and argue for a return to open access. These relatively few unhappy fishers argue that the IFQ system has essentially provided an unwarranted and unfair financial windfall to the initial quota recipients by awarding them shares that could be sold, traded, or leased for thousands of dollars.

Another serious problem faced by longliners is the sometimes very heavy bycatch of halibut that is taken in groundfish trawls. The trawlers and their bycatch are monitored by observers, and the fishery is often shut down prematurely when the bycatch limit is reached. Despite these trawl restrictions, which have greatly reduced halibut bycatch, any bycatch at all may seem like too much since it represents foregone profits in the halibut fishery.

Western Pacific Bottomfish

Locally important fisheries for bottom-dwelling species also occur in the Western Pacific. The bottomfish fishery encompasses a very broad area: the main Hawaiian Islands, the Northwestern Hawaiian Islands, the Territory of Guam, the Commonwealth of the Northern Mariana Islands, and the Territory of American Samoa. The larger vessels from Hawaii, manned by full-time handline fishermen, range far from port on trips of up to 10 days. The smaller vessels in the western territories fish nearer shore on daily trips, crewed by part-time or recreational fishermen.

Hawaii harvests about 90 percent of the total bottomfish catch in the nation's Central and Western Pacific EEZ, which consists primarily of squirrelfish snapper (*ehu*), longtail snapper (*onaga*), pink snapper (*opakapaka*), giant trevally (white *ulua*), black jack (black *ulua*), thick-lipped trevally (*butaguchi*), and a seabass bearing the mellifluous name *hapu'upu'u*. The

Honolulu is home to thousands of small commercial longline, net, and trap boats, as well as recreational vessels. *Dennis M. Weidner, NOAA Fisheries*

ABOVE: Large schools of Hawaiian bigeye jacks beckon droves of recreational and commercial fishermen. © *Brandon D. Cole.* **RIGHT:** Hawaii's magnificent beaches yield up jack, snapper, and other choice edibles to the skilled surf fisherman. © *Index Stock/Pat Harrison, Black Sands Beach, HI; Index Stock Photography, Inc.*

more tropical waters of Guam, the Northern Marianas, and American Samoa offer up a similarly diverse assemblage of snappers, jacks, scads, rudderfish, goatfishes, and groupers, as well as species of emperor that inhabit rock and coral outcroppings. Unfortunately, many species in the main Hawaiian Islands and Guam are heavily overfished, although those in the Northwestern Hawaiian Islands, American Samoa, and the Northern Marianas could probably bear some additional harvest. Even though federal management plans have been implemented, prevention of further overfishing will require action at the state level, since much of the Hawaii fishery occurs within that state's waters.

Another bottom-dwelling species, the armorhead, was the target of a fishery that began in 1968 with trawlers from the former Soviet Union and then attracted the Japanese fleet. The intense foreign fishing resulted in a steep decline of the armorhead stock, leading to mandatory limits on harvests from 1978 to 1984 in the very small area within the U.S. EEZ known as the Hancock Seamount. Yields of armorhead outside the EEZ remain almost disastrously low, and it is suspected that the continued closure of fishing to U.S. fishermen under a federal plan may not be sufficient to allow stock recovery either inside or outside the U.S. EEZ. These U.S. seamounts remain the only portion of the fishery currently under management.

Salmon

Pacific salmon stocks are undeniably this century's greatest fisheries management challenge. User conflicts are relentless, overfishing and bycatch occur in some areas, habitat loss and degradation are widespread, and jurisdictional disputes erupt everywhere. American salmon stocks are highly transboundary—that is, shared by both the United States and Canada and extending into international waters as well. Because the fish are anadromous, returning as "runs" to spawn in the very streams where they were themselves spawned, there is a great deal of international tension over captures by one side or another before the fish reach their natal waters.

In addition, though, because salmon migrate long distances, they're subject to interception by fisheries far from the Northwest; hence, the necessity for an international forum to address allocation issues. Salmon management is negotiated with Canada through the Pacific Salmon Commission, under the Pacific Salmon Treaty, but it can't be claimed that this is a smooth or effective process. Failed negotiations are common because catch restrictions, particularly on chinook sockeye and coho catches in Southeast Alaska, Canadian

The sportsman's dream: a prize catch from Salmon River, Oregon, sizzling on a streamside campfire. © *William B. Folsom Photography, Inc.*

LEFT: The livelihood of many Alaskans, such as this Kodiak woman, depends on a steady supply of premium wild salmon. *Charlie Ess, NOAA Fisheries.* **ABOVE:** Salmon smolts mill in freshwater streams before their arduous journey to the sea. *William B. Folsom, NOAA Fisheries.* **RIGHT:** Artificially spawned salmon make up much of the Columbia River's current fish production. *Joni Packard, NOAA Fisheries*

west coast troll and net harvests of chinook and coho, and U.S. Fraser River sockeye harvests in Puget Sound. The 1990s have seen great rancor and a breakdown of negotiations between Canada and the United States, and subsequent overly aggressive harvesting that has compounded forecasting errors and nearly destroyed one of the most productive runs of Canadian salmon, Fraser River sockeye.

International management is also facilitated by the North Pacific Anadromous Fish Commission. Representing Canada, Japan, the Russian Federation, and the United States, the Commission provides a framework to prohibit high-seas salmon fishing and trafficking of illegally caught salmon. This effort and the United Nations resolution banning large-scale pelagic driftnet fishing for squid (with its high salmon bycatch) have largely eliminated salmon harvesting on the high seas.

Spring chinook returning to the Columbia River are taken in gillnets, the most common gear for coastal salmon. *Joni Packard, NOAA Fisheries*

The distinctive life cycle of salmon is responsible for another great management difficulty. In ocean fisheries, it's nearly impossible to distinguish between individuals of a species spawned in different streams or between different runs from the same stream, especially where salmon from some streams are endangered. Trying to find a way to allow for fishing of nonendangered runs can be difficult and has led to the need for severe restrictions to protect endangered populations in mixed-stock fisheries. The problem is lifted to nightmare proportions by the sheer number of salmon species and runs (discrete spawning stocks that return to specific streams). Five distinct species are harvested—chinook (also known as king and tyee), coho (silver), sockeye (red or blueback), chum (keta or dog), and pink (humpback)—and each species may have hundreds of runs.

In addition to the complex salmon life cycle, effective management becomes nearly impossible because of the complexity of American economic sectors that either use the fish or use the environment that produces them. The most highly visible sector is the commercial fishery, with its dockside value for all Pacific salmon species combined of about $360–$460 million annually—about two-thirds of which comes from Alaska sockeye. Salmon revenues were the highest in 1988, but both landings and price have declined since then because of habitat inaccessibility or degradation and such large-scale environmental fluctuations as the recurrent El Niño phenomenon and cyclical drought conditions in the Northwest.

Salmon are enormously important everywhere: sportsmen treasure the fish and spend a great deal of time and money to catch them; Native American cultural uses of salmon are perceived as beyond any dollar value whatsoever; and large segments of the non-fishing population increasingly demand that rare salmon stocks must be preserved as a commitment to future generations of Americans. In addition to allocation conflicts, unending controversies erupt over fishery closures, nearly extinct salmon runs, habitat degradation (and the means to mitigate it), international and state jurisdictions, bycatch of salmon in other fisheries, the impacts of hatchery fish on wild stocks, and a host of other problems.

Although most salmon species occur in both Alaska and the Pacific Northwest, regional issues are somewhat distinct, and it's therefore helpful to discuss them separately.

Pacific Coast Salmon

The importance of salmon to the Pacific Coast is indisputable, with the animal elevated to the level of icon. Salmon images are everywhere, and if it weren't for the unfortunate implications associated with the species' spawn-and-die destiny, many regional universities would probably field "Battlin' Salmon" football teams. Beyond that, salmon seem to represent an almost sacred totem in the Northwest. Fishermen discuss their catch in reverent tones, and waiters and chefs wax eloquent about alder-smoked Copper River kings. The media focus on salmon is relentless from Alaska to Southern California and as far inland as Idaho, where some increasingly rare salmon stocks originate.

The succulent salmon steak—rapidly becoming a favorite American seafood. © *William B. Folsom Photography, Inc.*

Five salmon species are harvested along the Pacific Coast (six if steelhead trout, which is really another salmon, is included). The most highly valued are chinook and coho, harvested during their spawning runs in the ocean, sounds, bays, and coastal rivers. Chinook salmon, originating primarily in rivers and hatcheries in Washington's Puget Sound and Columbia River, Oregon's coastal rivers, and California's Klamath and Sacramento Rivers, are named for the season in which they migrate from the ocean to fresh water to spawn—for example, winter-run chinook. The other species—sockeye, pink, and chum—aren't fished in great numbers by west coast anglers, and aren't commercially taken except in Puget Sound. All species, however, are harvested by many Native American tribes for subsistence and ceremonial purposes.

Chinook and coho ocean fisheries are managed under a cooperative federal fishery management plan developed by the Pacific Fishery Management Council. However, the Puget Sound and Columbia River fisheries for these same species are managed by the

Keeping THE FAITH

Hundreds of coastal American communities boast fishing families that go back several generations. But John Dyasuk comes from a Yupik tradition that goes back to the dawn of historic fishing . . . and then some. Following the path of their ancestors, the extended Dyasuk family of Togiak nets fish in Bristol Bay, along the edge of Alaska's fierce but immensely productive Bering Sea. Unlike former generations that used artisanal methods to fill their larders, however, the Dyasuk operation is a modern, successful commercial enterprise that helps supply the nation's hunger for Alaskan salmon.

Fishing remains an honored and fulfilling way of life for many indigenous American fishing communities in Alaska, the Pacific Northwest, Hawaii, and the Western Pacific. For many groups, the catch has a cultural meaning beyond its value as food. In some villages, fishing may have remained at the artisanal level, using gear fabricated by the fishers themselves—spears, lines, traps, fish wheels, weirs, and impoundments—and conducted from shore or kayak. But most indigenous peoples in the United States and its territories now use power boats and manufactured gear that make their operations competitive with those of other, non-native regional fishermen. In so doing, the original harvesters of America's living marine resources have found a way to maintain their cultural heritage as they sustain a fulfilling livelihood in their own communities.

John Dyasuk, Togiak, Alaska (Karen Ducey, NOAA Fisheries)

SAN JUAN FISH CO.
SEATTLE

Puget Sound fishermen in the late 19th century show off the huge salmon taken in nearshore beach seines. *Museum of History & Industry, Puget Sound Maritime Historical Society*

states and tribes. The other species—pink, chum, and sockeye—are managed by the Pacific Salmon Commission, the state of Washington, and tribal fishery agencies.

A surprising variety of gear is used to take salmon. Commercial Northwest ocean harvests are most commonly trolled, but in Washington's Puget Sound, gillnets and purse seines are also used (gillnets are used almost exclusively in streams and estuaries). Tribes depend on gillnets, purse seines, hook-and-line, and the traditional dip nets and spears that have long been used for ceremonial subsistence harvests. But it is the realm of recreational fishing that has elevated salmon fishing into a sublime art. Almost everywhere along the Pacific Coast, fishers troll the open ocean from specialized boats, cast with spinning tackle from small boats in estuaries and bays, and hike far up coastal streams and rivers, often wading chest high into the river itself to wield the ultra-challenging fly tackle.

Landings of most wild salmon species fluctuate widely, depending largely on ocean conditions, freshwater habitat quality,

LEFT: Salmon, like these being unloaded in Oregon, have long been important to the coastal recreational fishing industry. © *Chuck Schmeiser/Unicorn Stock Photos.* **RIGHT:** Pacific Northwest dams must take much of the blame for depleting some salmon stocks. *Courtesy of Gene Cope, NOAA Fisheries*

hatchery production, and management regimes. Droughts, El Niño or other ocean warming, and shifts in currents play a major role in the year-to-year availability of these fish, which generally live just a few years and spawn only once. Unfavorable sea conditions, combined with degraded and diverted rivers and streams and overfishing, have reduced many salmon stocks or runs—especially chinook and coho—to the point where they're listed as endangered or threatened under the Endangered Species Act. The issue is not minor: the highly respected American Fisheries Society, representing the majority of North America's professional fisheries scientists and managers, has identified more than 200 separate stocks of Pacific salmon that are "at risk" and in need of protection.

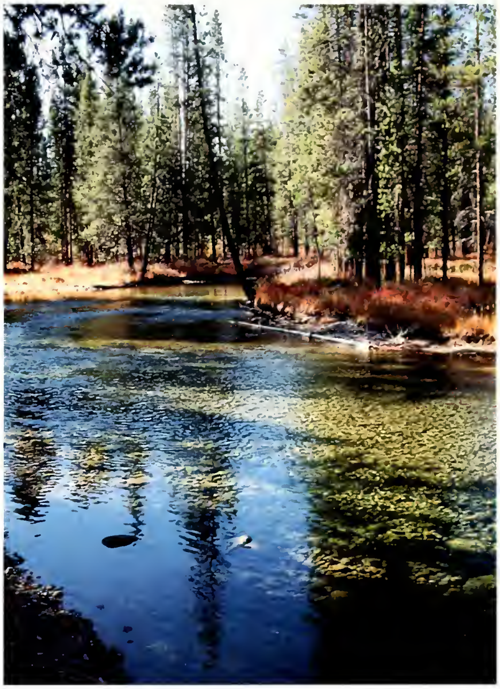
As a result of actual and proposed listings and declines of some other stocks, state and federal managers have had to drastically restrict ocean harvests in recent years. The resulting closed fisheries may affect many commercial fishermen and charter boat owners who depend almost entirely on salmon fishing. Closures bitterly anger fishermen, who insist that the real villains are the giant hydropower dams that for generations have blocked the downstream migration ("escapement") of young salmon, and long-term habitat degradation.

The habitat issue is a primary salmon concern from the Columbia River Basin to central California, although hatchery straying, hydropower, and harvests have also played roles in salmon management problems. The dependence of salmon on fresh water for spawning and rearing of the fry has made them particularly vulnerable to stream degradation by mining, logging, agriculture, livestock grazing, and urbanization. Alternative water needs for hydropower, irrigation, and municipal and domestic uses directly compete with salmon for the fresh water on which they depend. Increasing water needs for agriculture and the burgeoning west coast human population make survival of some—or many—salmon stocks doubtful.

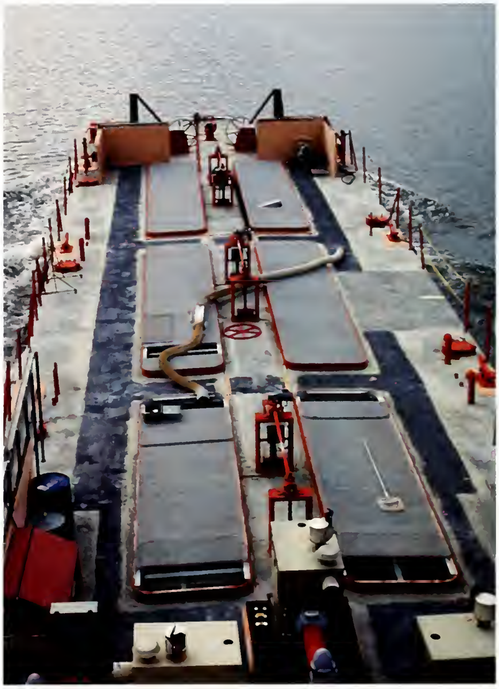
Because the quality of salmon habitat is directly influenced by land management practices, salmon management necessarily involves the cooperation of the U.S. Forest Service, Bureau of Land Management, Fish and Wildlife Service, Bureau of Reclamation, Army Corps of Engineers, Environmental Protection Agency, Bonneville Power Administration, state resource agencies, Indian tribes, municipal utility districts, agricultural water districts, private timber companies, and landowners.

Many fishing and environmental groups have an overarching goal of reestablishing healthy watersheds that support naturally spawning salmon runs. Some regional industries, though, maintain that such watersheds aren't compatible with their needs. They see river "drawdowns" (which reduce the water level in reservoirs behind dams to increase water speed and salmon fry migrations) as unacceptably raising operating costs. If there are thousands of salmon fishers in the Northwest and hundreds of thousands more citizens, farmers, and industry executives also influenced by salmon issues, there are at least that many distinct opinions as to how salmon should be managed. Salmon management is a continuing headache of monumental proportions.

Recent salmon allocation demands by Native Americans have become another contentious issue. Federal courts have upheld treaty claims that give regional tribes a significant portion of the fish. In



ABOVE: Redfish Lake Creek, historic route of a distinct salmon run, today sees only a few of the endangered fish each year. **BELOW:** Salmon fry are barged down the Columbia River to avoid the heavy mortalities associated with giant hydroelectric dams. *Photos by Joni Packard, NOAA Fisheries*



fact, salmon are so important to Pacific Coast tribes that the Magnuson–Stevens Act established a voting seat on the Pacific Fishery Management Council exclusively for a member representing Native American interests.

Many national and regional conservation organizations have become powerful advocates for the salmon. The region's first salmon harvesters, the Native Americans, have also strengthened their collective voice. The Columbia River Inter-Tribal Fish Commission—consisting of the Nez Perce, Umatilla, Warm Springs, and Yakama tribes, which were awarded substantial fishing rights under an 1855 treaty—is a major influence on salmon issues affecting the entire Columbia Basin ecosystem. (The far-upstream Shoshone–Bannock also participate, but through a separate treaty with Idaho.) The more numerous coastal Washington–Puget Sound tribes are represented by the Northwest Indian Fisheries Commission, but these and other Native American groups work closely with the Pacific Council's designated tribal seat.

Pacific Coast tribal organizations have banded together to work for salmon conservation and treaty fishing rights, but hostility remains where tribes are perceived as garnering an unfair share of the increasingly scarce resource. Non-native fishermen sympathize with the long-historic role of salmon in tribes' spiritual and cultural identity, and are willing that some salmon should be allocated for those purposes. Amiability has sometimes turned to animus when tribal allocations are sufficiently large—sometimes as much as half—to permit Native Americans a real livelihood from salmon fishing—that is, selling the catch. But much of the media attention on tribal issues has stemmed not from non-native fishermen, but from corporate and landowner interests intent on ensuring that their access to water resources isn't hampered by salmon conservation measures.

There are other skirmishes in the "salmon wars." One of the strangest is a snarl of fish and sea lions, with fisheries managers trying to determine which protected species should have priority. For it means shielding the scant steelhead and salmon runs migrating through Seattle's canal locks from the voracious but equally protected sea lions lying there in wait for them. This environmental chess game has seen resource managers scrambling to protect all participants in the fray. Bubble curtains and underwater sounds have been generated to ward off sea lions, and the maverick mammals have been trucked southward, to the ire of California fishermen finding the animals raiding their own nets and lines—ultimately a futile strategy as the sea lions tend to make a beeline back to Puget Sound. Finally, in desperation, a federal exemption has been granted to kill the worst marauders, but the ensuing horror and wrath of animal lovers across the nation have made this, also, a controversial solution.

Still another salmon battle is being fought by salmon fishermen and salmon farmers. Over the past two decades, Washington, particularly, has developed profitable salmon culture operations, and the extensive pens are a common sight in

LEFT: The last remaining commercial Native American fishery on the Columbia River takes fall chinook in gillnets. *© Yvonne Smith, Columbia River Inter-Tribal Fish Commission.* **ABOVE:** Native Americans in the 1950s used scoop baskets to catch returning salmon at Celilo Falls, Washington. *Courtesy of the Columbia River Inter-Tribal Fish Commission.* **RIGHT:** Bag nets were also used by Native Americans to take Columbia River salmon in the 1950s. *Scientific Publications Unit, NOAA Fisheries*

ABOVE: Sea lions use log rafts for a haul-out as they wait in Everett, Washington, for the returning salmon. *Pat Gearin, NOAA Fisheries.*
RIGHT: Aquaculture operations, like this one near Seattle, have helped boost salmon popularity nationwide. © *William B. Folsom Photography, Inc.*

nearshore waters. America's salmon farmers face a host of problems—fish diseases and parasites, predation by mammals and birds, adverse weather, and a glut of cheaper farmed salmon from Europe and Chile. But in spite of serious setbacks, such as the massive spread of hemorrhagic salmon disease a few years ago in Puget Sound, salmon farms are a growing business. A large market across the nation receives high-quality products that have helped keep prices for wild salmon—and fishermen's profits for both the west coast and Alaska—far below those of former years.

Alaska Salmon

Unlike the Northwest's reliance on chinook and coho, sockeye and pink catches dominate in Alaska, although all five species are considered fully utilized. In the case of sockeye, some stocks are even larger than known historic levels, to the point of burdensome surpluses and lowered market prices. It is important to remember that in Alaska's remarkable 34,000-mile coastline, more than 14,000 water bodies support salmon populations. And unlike the Northwest, with its troll and longline fisheries, Alaska salmon are also commonly taken by commercial netters.

Also unlike the Northwest, salmon management in Alaska has proven effective, as a result of cooperative management by state and federal agencies, a wealth of pristine habitats, reduction of the salmon bycatch in other fisheries, extensive hatchery production, favorable ocean-rearing conditions, and elimination of foreign high-seas driftnet fisheries, which formerly took a heavy toll on these fish.

Alaska salmon management is predominantly by the state, since the majority of the fish are harvested in state waters, with EEZ salmon harvests managed by both Alaska and the U.S.–Canada Pacific Salmon Commission. Alaska Native American groups take a considerable harvest, but fisheries issues aren't related to treaty rights as in the Northwest. Alaska Natives' resource use rights are protected under the Alaska National Interest Lands Conservation Act.

In spite of Alaska's management success, the state is now facing some of the Northwest's salmon problems, especially those associated with increasing competition for freshwater habitat. Extractive industries—especially logging, mining, and oil and gas production—demand changes in land-use laws to expand development, but such uses may lead to eventual loss of salmon production.

And while the directed salmon fisheries have themselves largely eliminated bycatch, the incidental take of salmon in Alaska's groundfish fisheries remains a serious problem. Many salmon are taken each year, amounting to foregone benefits for salmon fishermen. Time-area closures and bycatch limits are currently used to limit this take, but the groundfish industry and managers are hopeful of developing programs that give groundfish vessels a real incentive to avoid salmon areas in the first place.

Salmon hatcheries pose still another serious problem. Alaska's salmon enhancement program produces a great many fish for commercial and recreational harvest, mostly from private-sector hatcheries licensed by the state. In some areas, such as Prince William Sound, large returns of these hatchery salmon mix with much lower numbers of wild fish, and the state must find ways to minimize catches of the wild fish to prevent their stocks from being depleted. In addition, large hatchery programs tend to support intense fishing, so that weak natural runs are depleted by the overfishing subsidized by the hatcheries.

TOP: Some of Alaska's finest salmon are taken on the Copper River by a fleet based in Cordova. *Scientific Publications Unit, NOAA Fisheries.* **CENTER:** Iced Pacific salmon are unloaded from the hold of an Alaska salmon boat. © *Brad Matsen.* **BOTTOM:** Restrictions on salmon harvesting mean lean times for family operations, like this one in Cook Inlet, Alaska. © *Mandy Merklein*

Pacific Highly Migratory Pelagics

Like its Atlantic counterpart, the Pacific highly migratory pelagics group consists of swordfish, marlin, sailfish, spearfish, tuna, and oceanic sharks. It also includes two other important species—dolphin fish (mahi mahi) and wahoo, an elongated mackerel-like fish. But it is the tuna and swordfish resources that command most of the fishing effort … and most of the publicity.

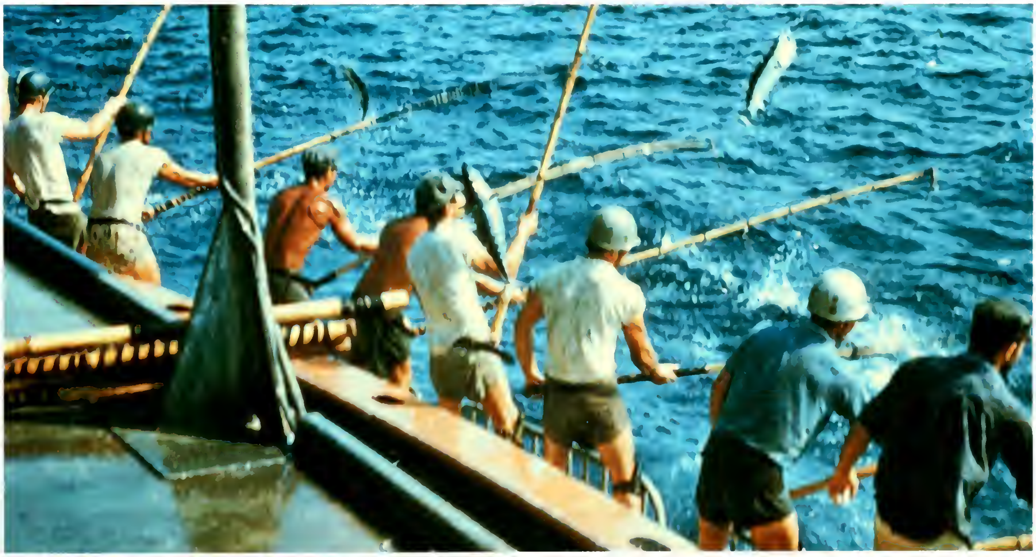
If cod and herring heralded the advent of fisheries' wealth to the east coast, that role was fulfilled on Pacific shores by tuna more than a century later. The U.S. tuna fleet's founding fathers—who were originally fishermen in their homelands of Portugal, Italy, Scandinavia, and Yugoslavia—were actually seeking fortunes in California's gold fields in the mid-19th century, not riches in its coastal waters. Unlike the sea's resources, gold carved from the earth doesn't grow back, and very quickly was unavailable to these newcomers. The unsuccessful immigrant diggers had to turn elsewhere for a living, and that "somewhere" was the sea, which rewarded them and their descendants, with highly profitable—if uncertain—yields.

The growth of canneries after the turn of the century breathed life into the tuna fishery. Tuna canning is said to have originated with the 1903 failure of the Pacific sardine to appear in Southern California. By 1907, canning methods had been developed that are essentially those still followed today. Albacore was the first canned tuna to be successfully marketed, and the industry expanded rapidly. However, the albacore fishery was seasonal and erratic. (Both albacore and bluefin are temperate species, while the others are tropical and available year-round.) So in 1917, canning began for yellowfin, skipjack, and bluefin tuna to feed World War I troops. Because the local supply was inadequate to meet the demand, by 1927, about 80–90 percent of the catch came from waters south of California, primarily off Mexico, Ecuador, and Peru. The 1925 development of the legendary tuna clipper, equipped with mechanical refrigeration to freeze the catch and wells to hold live bait, made possible this long-distance fishery.

ABOVE: The Tuna Sandwich—lunchroom icon for generations of Americans. © *William B. Folsom Photography, Inc.* **RIGHT:** The imprint of proud immigrants shows on this older wooden tuna purse seiner in San Pedro, California. *William B. Folsom, NOAA Fisheries*

The earliest tuna fishing technique used live bait to attract tuna to the stout bamboo poles used in this early fishery. The upward-striking tuna literally flew from the water as they attacked the flashing metal hook in the midst of the thrashing bait fish, letting fishermen direct enormous fish over their heads. When the fish were too big for one man, two or more attached their poles to a single line. Such

Helmets protected albacore fishermen in the 1960s from the fish "flying" overhead onto the deck. *Scientific Publications Unit, NOAA Fisheries*



PROCESSING TUNA: PUTTING BIG FISH IN LITTLE CANS

What table in America hasn't offered up that unpretentious but soul-satisfying creation—the tuna sandwich? Whether chunk light (usually yellowfin or skipjack tuna) or solid-pack (usually the premium albacore), these giant fish move from boat to can swiftly and efficiently. Shown here are some of the processing steps at a large, modern cannery in Mayagüez, Puerto Rico, which handles tuna from both the Pacific and the Atlantic.

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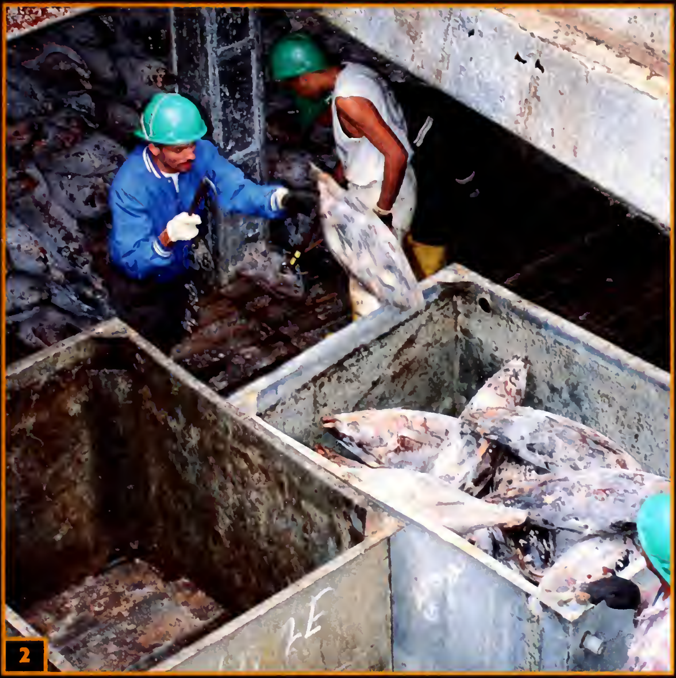
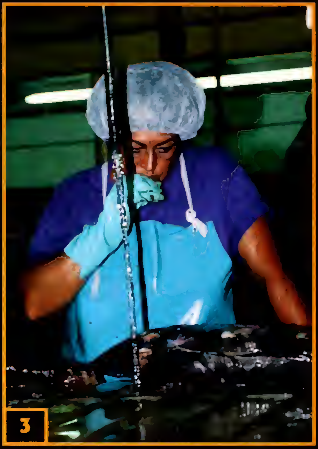
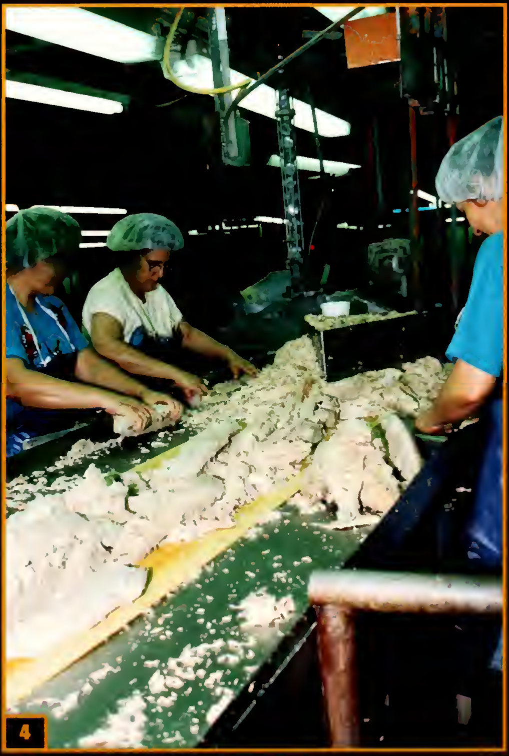




[1] VERY LARGE, FROZEN ALBACORE ARE OFFLOADED INDIVIDUALLY FROM SHIP TO CANNERY DOCK. [2] DOCK HANDS UNLOAD SMALL (15- TO 30-POUND) ALBACORE FROM THE HOLD OF AN OCEAN-GOING FREIGHTER. [3] IT MAY LOOK A BIT PRIMITIVE, BUT AN EXPERIENCED "TUNA SNIFFER" CHECKING THE GILLS IS STILL THE BEST WAY TO DETECT "OFF" FISH. [4] WORKERS ON THE LINE HAND-CUT THE COOKED AND CLEANED MEAT INTO BLOCKS OF SOLID "WHITE MEAT" TUNA FOR CANNING. [5] A TECHNICIAN PREPARES CARTLOADS OF FRESHLY CANNED ALBACORE FOR THE "RETORT," A GIANT PRESSURE COOKER THAT ENSURES THE CANNED PRODUCT'S SAFETY. [6] LITTLE OF THE ALBACORE IS WASTED DURING PROCESSING. THE DARK MEAT, DISLIKED BY HUMANS FOR ITS STRONG TASTE, IS A PREMIUM PET FOOD PRODUCT FOR EXACTLY THE SAME REASON. *PHOTOS BY WILLIAM B. FOLSOM, NOAA FISHERIES.*



LEFT: Most of the U.S. tuna fleet has relocated to Samoa, but some boats are once again fishing out of Los Angeles. *William B. Folsom, NOAA Fisheries.* **ABOVE:** American Samoa's Pago Pago is now the home port for much of America's tuna clipper fleet. © *Bonnie J. Ponwith*

pole fishermen could land tuna at the rate of several tons a day.

The invention of the power block and nylon nets permitted the California fleet to revitalize by converting to purse seine operations—and, subsequently, bigger and faster vessels that could set even bigger nets and carry even more frozen fish. Purse seine fishing is today the primary gear for yellowfin and skipjack in both the Eastern Tropical and the Western Pacific.

At one time, the tuna processing and harvesting sectors were highly integrated—processors owned shares in the vessels or entered into long-term contracts with independently owned vessels to ensure a steady supply of tuna. By the 1970s, however, many foreign countries were also supplying tuna to the U.S. market as well as to their own processors who had lower operating costs. To take advantage of the new supplies of tuna, and to become more competitive with the aggressive foreign processors, U.S. processors soon began divesting themselves of interests in U.S. vessels. Without processor backing, many vessels were forced to leave the fishery.

With the identification of potentially more abundant tuna resources in the Western Pacific, U.S. processors abandoned the Southern California canneries and relocated to American Samoa, attracted by its tax benefits and lower labor costs. This move required major technological changes in vessels originally designed to fish in the Eastern Tropical Pacific, and for many boats, such refitting wasn't feasible. Thus, many purse seiners either left the fishery or were sold to foreign-flag operations—contributing further to the supply of foreign-caught tuna.

In 1997, landings of all species of tuna for canning brought U.S. fishermen more than $175 million. Much of this comes from international waters and foreign coasts, rather than from domestic waters. Of the five tunas that make up the commercial "lightmeat tuna" catch, skipjack is by far the dominant species, almost three times the yellowfin catch. However, albacore, with far smaller catches than even yellowfin, commands a higher price than the other species canned—this is the select "white meat" tuna favored for the priciest sandwiches.

A look today at the total production of canned tuna reveals a global picture. The two canneries in American Samoa and two in Puerto Rico process most of the U.S. tuna pack, valued recently at almost $1 billion a year. Most of the tuna processed is yellowfin and skipjack, and about 25 percent is albacore. The availability of the raw product varies greatly as a result of global tuna stock conditions, market prices, and weather. Some tuna canning has returned stateside with the opening of two plants in California. In addition to tuna for canning, though, many local markets handle fresh tuna steak's (yellowfin and albacore) that command high prices at "white-tablecloth" restaurants, as well as carrying even higher-valued bluefin, bigeye, and yellowfin for the raw fish cuisine at sushi bars.

Purse seining for tuna is well known in the United States, not so much because it takes a lot of tuna, but because it also took—and inadvertently killed—a lot of dolphins associated with those tuna. Tuna fishermen had long noticed that porpoise are often found swimming directly above yellowfin tuna, and in the 1950s, purse

Raw tuna, at far right, is one of the premium products demanded for the growing sashimi market. © *William B. Folsom Photography, Inc.*

seiners began to deliberately seek these tuna–dolphin schools, setting the nets around both them and the tuna. This procedure is known as "dolphin fishing."

The growing conservation movement of the 1960s led to the Marine Mammal Protection Act in 1972, which protected dolphins against such practices. However, heavy dolphin bycatch by other fleets has continued to the point where some stocks are depleted years after dolphin fishing by American vessels ceased. These takes have worried many fishermen, who tried to find ways to release dolphins while retaining the targeted tuna.

One successful method proved to be "backing down" the net, reversing the direction of the vessel after two-thirds of the net has been retrieved. The net is formed into a long channel instead of a circle, with the trapped dolphin at the end farthest from the boat. The fishermen wait until the tuna are near the vessel and back the vessel up quickly, causing the cork line to submerge and permitting the dolphin to escape. It may take several such maneuvers to release the dolphins.

Even with these modifications, purse seining killed too many dolphin, especially in the non-U.S. fleet. Growing consumer anger finally led to a "dolphin-safe" policy in 1990, making it illegal to buy tuna from suppliers who couldn't certify that the product was "dolphin-safe." This policy eventually became law and, until recently, precluded American purchase of any Eastern Tropical Pacific tuna caught in the course of dolphin fishing. Changes in federal law in 1997 allow for a small amount of fishing on tuna schools associated with dolphin.

A strong conservation movement helped ban tuna fishing that took spotted and other dolphins. *Scientific Publications Unit, NOAA Fisheries*

A considerable amount of tuna, primarily yellowfin and bigeye, is also taken by longlining, especially across the Pacific where tuna are dispersed at depths of more than 300 feet. Foreign fleets have lines up to 40 miles long, with 2,000 baited hooks per day; America's fleets fish with shorter lines and fewer hooks. Though it may take 4 hours to set the hooks, retrieving them can take up to 15 hours, making longlining essentially an around-the-clock, exhausting operation.

Because albacore don't school, they too are taken by longlines, pole-and-line fishing, and trolling. About 600 albacore trollers work off the California, Oregon, and Washington coasts, but unlike tuna purse seiners, these boats are easily adapted for use in other fisheries, such as salmon or crab. Consequently, Pacific trollers tend to alternate among these three fisheries, depending on the availability and price of each resource. There is also a smaller, distant-water fleet of albacore trollers in the South Pacific and the North Pacific, many of which return to the west coast at the close of the fishing season.

The advent of purse seining created the very real possibility of overfishing and led in 1966 to recommendations by the Inter-American Tropical Tuna Commission for regulation of at least one species, bigeye tuna. Since 1980, however, regulations have been suspended because Mexico, the primary tuna-fishing nation in the Eastern Tropical Pacific, isn't currently a

LEFT: Seiners can now release most dolphins unharmed, but most U.S. boats currently fish where tuna don't school with dolphins. *Scientific Publications Unit, NOAA Fisheries.* **BELOW:** Almost all canned tuna currently sold in the U.S. bears a "dolphin-safe" symbol on the label. *William B. Folsom, NOAA Fisheries*

BLUE MAX
MAALAEA

ABOVE: Buyers at the Honolulu fish market inspect bluefin tuna carcasses before offering top dollar. *Courtesy of Pacific Fishing magazine.* **LEFT:** Happy sportsmen off Hawaii land one of the marlin that have made the state a game fishing paradise. © *Index Stock/VOLVOX*

Commission member. In the Central Western Pacific, the Forum Fisheries Agency, composed of South Pacific island nations, has instituted a licensing program for foreign fishing fleets through access agreements. The U.S. fleet is currently authorized under one such agreement—the South Pacific Regional Tuna Treaty—to license up to 55 purse seiners. There are also other management regimes, such as the multilateral scientific agreement for albacore, tuna, and tuna-like species in the North Pacific. Longline fishing for tuna and swordfish in the Hawaiian Islands, American Samoa, Guam, and the Northern Mariana Islands is managed under a federal plan.

The recreational fisheries for tuna, marlin, and sailfish are important to both the west coast and Hawaii, with some of the world's most ardent anglers competing for these oceanic giants. The recreational catches from charter trollers and private boats in both geographic areas are important, but the volume is unknown in Hawaii, where most of the highly migratory pelagics catch by charter boats and other recreational vessels is legally sold, and it's often difficult to determine whether landings should be considered commercial, recreational, or subsistence.

California presents a very different picture of the recreational fisheries for these species. The entire state abounds with private recreational boats and yacht marinas outfitted for the big pelagics and willing to brave the turbulent offshore waters, especially seaward of Catalina and the other Channel Islands. In addition, the immense and wealthy San Diego-based charter fleet takes large numbers of affluent U.S. and Canadian sportsmen on week-long trips into Mexican waters in search of bluefin and yellowfin tuna, marlin, and other species. The jaunts, under carefully negotiated agreements with Mexico, yield some spectacular fishing for American anglers and hefty taxes for Mexican coffers. Migratory pelagics are also taken in considerable numbers by charter and private boats.

Fishing for swordfish in the Pacific, as in the Atlantic, is mostly commercial. Much of the Pacific-wide swordfish catch is taken on the high seas by Japanese longliners targeting tuna. The U.S. fleet consists primarily of longliners operating out of Hawaii, with some from California. Fishing grounds range throughout the Central Pacific as far as Alaska in the north and American Samoa in the south. Some swordfish are also taken by harpoons and handlines, especially in California. Swordfish harpooning vessels are readily recognizable: as in the Atlantic, they sport a high lookout, or "flying bridge," and a long bowsprit with a small platform at the end to let the harpooner get as close to the fish as possible. Catch data suggest that the swordfish stocks aren't overfished and may even be slightly underutilized. The Hawaii longline fleet is actually a distant-water fishery in the sense that vessels usually travel more than 500 miles to reach the fishing grounds. These boats

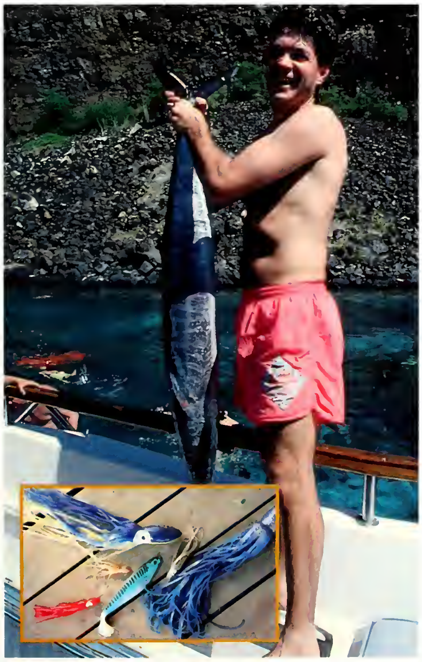
PROWLER
SAN DIEGO

Partyboats make sure their paying customers arrive home with a good catch, in this case, yellowfin tuna. *William B. Folsom, NOAA Fisheries*

A Hawaiian longliner for tuna and swordfish ties up at a Honolulu processing facility. *Dennis M. Weidner, NOAA Fisheries*

are relatively small (about 70 feet) and relatively few (about 125).

Unlike the Atlantic billfish resource, where only recreational catches of marlin, sailfish, and spearfish are allowed, sale of billfish is allowed in Hawaii but not on the mainland. Two species—blue and striped—dominate the marlin catch, with a third species—white marlin—less common. One also sees sizable landings of sailfish, shortbill spearfish, wahoo, mahi mahi, and several oceanic shark species (requiem, thresher, hammerhead, and mackerel). These other species are generally more abundant near islands, continental slopes, and seamounts and so can be captured by relatively smaller vessels, including charter and private boats, without going very far from home.



Large wahoo reward recreational fishermen in Hawaii with a good fight and a superb dinner. *© William B. Folsom Photography, Inc.* **INSET:** Success when fishing Pacific billfish and tuna requires great skill, eternal patience, and a good collection of artificial lures. *© Index Stock/Jacque Denzer Parker*

Longlines, trolling, and handlines are used for commercial catches of billfish, wahoo, and mahi mahi, with sharks taken by longlines in Hawaii and by harpoon and drift gillnets along much of the nation's west coast. Unfortunately, there isn't a lot of good information on the status of these species, although except for blue marlin, none appear to be overfished. One problem with this assumption is that there is no international consensus on gathering and reporting statistics and setting up a conservation and management group to encompass all interests.

Even domestic management of highly migratory species is difficult and sometimes appears inequitable between fishermen in different parts of the animals' range, especially for swordfish and marlin. Within the U.S. EEZ of the Central and Western Pacific, species are managed under a federal plan. However, California and Alaska vessels haven't been subject to the regulations developed under this plan for Hawaii-based fishermen, even though all of them are fishing on the same swordfish resource. And California's army of billfish anglers ferociously defends its state ban on selling marlin, while these fish can legally be sold in Hawaii. These differences have made problematic attempts to get fishermen from California, Oregon, Washington, Alaska, and Hawaii to agree on a single management regime.

As a result of the heavy harvesting of so many migratory pelagics, many of them have become targets for aquaculture. The common perception is that pond culture isn't suitable for such large, swift animals. And indeed, no serious effort has thus far been attempted to farm swordfish or billfish. But Japanese and New England success with several tuna species, including the mighty bluefin, has caused investors to rethink the potential for farming migratory pelagics. Aquaculture researchers in Hawaii have shown that mahi mahi, which is a prized "white-tablecloth" species, can be cultured, although it can't yet compete economically with ocean-caught mahi mahi. (The Hawaiian name means "strong strong," a fitting tribute to this schooling fish's fighting ability.)

Mahi mahi is increasingly in demand throughout the world. American longline and gillnet fishermen supply only a small portion of the nation's mahi mahi consumption, but domestic supplies come from both the Atlantic and the Pacific. In fact, restaurant-goers are sometimes confused to see menus offering the single species as both "mahi mahi" (generally from the Western Pacific and higher priced) and "dolphin fish" (often from the Gulf of Mexico).

Sharks are deserving of special mention because of their historic and continuing importance in California, where many of the higher-value shark species are found—Pacific angel, leopard, thresher, shortfin mako, blue, and cow. Skates and rays are also harvested for their "wings," to supply imitation scallops. These cartilaginous fishes are targeted by commercial as well as recreational fishermen, and occur as bycatch in both sectors. Some of the shark bycatch in the groundfish and longline fisheries is used for human consumption, with shark fins being of particular interest recently. Unfortunately, most of the carcass is discarded.

Thresher shark, in particular, is highly prized for its meat, which aficionados insist tastes better than swordfish. Mako and blacktip sharks are also taken in commercial quantities, but many restaurant chefs will only buy these species when thresher isn't available. Most of the west coast catch consists of the common or "green" thresher, but the less common pelagic thresher is also taken. Some of the Pacific shark harvest is by longliners, but a large portion comes from gillnetters

LEFT: A mako shark taken in this False Pass, Oregon, salmon gillnet may bring unexpected income if it's in good shape. *Courtesy of Pacific Fishing magazine.*
TOP RIGHT: Demand for the meat, fins, and cartilage has expanded the west coast shark market. *William B. Folsom, NOAA Fisheries.* **BOTTOM RIGHT:** Mahi mahi, swordfish, and other prized pelagics are always in demand at west coast seafood restaurants. *William B. Folsom, NOAA Fisheries*

Shark's Fin Soup
Chondroitin Sulf

THE FISH MARKET seafood market &
THE FISH MARKET

LEFT: Both recreational and commercial boats targeting billfish and swordfish use this marina in Dana Point, California. *William B. Folsom, NOAA Fisheries*
RIGHT: North Pacific trawls bring up many sharks, but most have little dockside value and are discarded at sea. © *Allen M. Shimada*

fishing California waters prior to the opening of the fall swordfish season.

For the first half of the 20th century, two other west coast sharks—spiny dogfish and soupfin—were fished heavily for the vitamin A concentrated in their liver. Commercial shark fishing during and immediately after World War II greatly reduced these stocks, but the postwar collapse of the natural vitamin A market brought the fishery to a halt, which allowed the subsequent recovery of these species. Recent years, however, have seen a strong demand for sharks for other products—steaks, fins for soup in the Asian market, shark cartilage purported to benefit arthritic joints, and shark's blood, alleged to inhibit or eliminate some retroviruses and malignant tumors.

Several Pacific Coast sharks offer a greater harvest potential to supply these products, but are susceptible to overfishing because of their slow growth and very low reproductive rate. Thus, both state and federal fisheries managers, spurred by environmental and sportsmen's groups, are concerned about declining shark populations, for which there currently is no management plan.

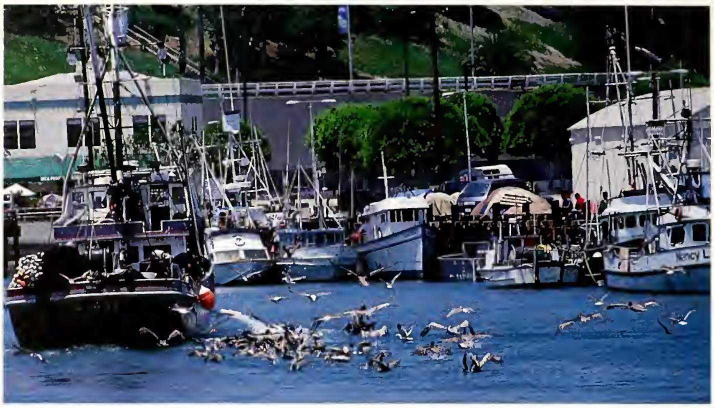
Pacific Coast and Alaska Pelagics

As in the Atlantic, this group is composed of several coastal species, some of them comprising very large populations. Along the Pacific Coast, five pelagics are harvested commercially, but the recreational fisheries for these are quite small. The fisheries for Pacific sardine, northern anchovy, and mackerel (jack and Pacific, or chub) are primarily concentrated and harvested off California and Baja California, while Pacific herring are taken all the way from California to Alaska. The anchovy and jack mackerel resources are managed under two separate federal plans, and sardine, herring, and chub mackerel are harvested under State of California plans. An allied species—squid—is often lumped with the pelagics, especially for management purposes; it is discussed later in this chapter under "Molluscs."

Although relatively small now, California's sardine fisheries were once of great importance to the entire nation. These small silvery fish are now used primarily for bait. During the 1930s and early 1940s, California sardine supported the largest fishery in the Western Hemisphere; indeed, it was one of the largest fisheries in the world. The sardine fishery was begun by the tuna canneries in 1915, primarily to help supply food for World War I troops and feed for increasing poultry production. Within a few years, enormous harvests were required to satisfy the nation's mania for canned sardine. In Monterey, Los Angeles, San Diego, and other California cities, sardine canneries provided thousands of jobs to otherwise unskilled laborers, including many Mexican-American and Italian-American immigrants.

Today's tiny sardine fishery is a ghost of its former great presence. Derelict canneries remain as unhappy reminders of the need for sound management, although a few of them are being resurrected as quaint restaurants, shopping arcades, and other coastal attractions. And the labels on sardine cans appearing on market shelves

An old Los Angeles sardine cannery sits empty, a stark reminder of the need for careful fisheries management. *William B. Folsom, NOAA Fisheries*



LEFT: A favored snack until the 1950s stock collapse, canned sardine still has a nostalgic following. © *William B. Folsom Photography, Inc.* **RIGHT:** Boats at Los Angeles' Terminal Island target many coastal species, including anchovy, squid, mackerel, and tuna. *William B. Folsom, NOAA Fisheries*

today show almost an exclusively foreign origin, or, in the case of "Maine sardines," a reliance on young herring.

The true sardine, like other Pacific Coast pelagics, is subject to wide natural fluctuations in abundance. The relentless and largely unregulated fishery consequently engaged in a boom-and-bust cycle that led finally to a total collapse in the late 1950s of both the sardine stocks and the lampara net industry that depended on them. This crash was once thought to be solely the result of overfishing. But recent evidence suggests that natural sea temperature cycles probably also control abundance, alternately favoring either anchovy or sardine dominance in what is essentially the same ecological niche. In retrospect, the intensive fishing pressure exerted on sardine over many years probably accelerated a long-term pattern of natural decline resulting from colder waters.

The sardine biomass was almost negligible for about 40 years following the collapse. But the absence of fishing has permitted it to increase by 30–40 percent each year since 1986, and commercial fishing has resumed. The resource, managed by California, appears to be steadily expanding. Low domestic dockside prices, tight regulations, cheap foreign sardines, and a reduced American taste for the canned product suggest an unlikely repetition of the California sardine fiasco. On the other hand, there seems to be a quaint but growing specialty cuisine for fresh sardine—chefs in some of the nation's toniest eateries are offering filleted and deboned sardines fried, baked, grilled, and roasted, or ground into exotic and spicy ravioli fillings and lasagnas. Most of the fresh sardine market appears to be met through European imports, but the homely little California sardine may increase in stature if it enters the American restaurant trade in any numbers.

Like the sardine, the northern anchovy is a favored bait for big game fish. Unlike the sardine, though, it has never enjoyed strong demand as human food, although the resource has small markets for fresh, frozen, canned, and paste products. Anchovy is also harvested for reduction into fish meal, oil, and soluble protein products. Its greatest importance may not be to humans but to the marine ecosystem: everything seems to eat it. For example, threatened brown pelicans, other seabirds, seals, sea lions, dolphins, and a great many carnivorous fish depend heavily on anchovies as a prime food source. As a result, management measures for the California portion of this resource shared with Mexico must take into account the needs of all these predators. Although the abundance of sardine is currently low, landings in California have fluctuated more in response to market conditions than to stock abundance, and the resource is not currently fully utilized.

LEFT: A few portside jobs, such as icing down anchovies, are still to be had at Los Angeles' Terminal Island. **BELOW:** Asian immigrant communities have helped build a steady market for such west coast pelagics as squid and mackerel. *Photos by William B. Folsom, NOAA Fisheries*

Jack Mackerel
CALIFORNIA SQUID

Of the two pelagic mackerel species, Pacific (chub) mackerel comprises far the larger portion of the catch. Although the species is found worldwide, on the west coast it's concentrated south of Point Conception. Pacific mackerel supported a large California fishery in the 1930s and 1940s, but the heavy exploitation eventually led to a stock collapse, bringing fishing to a halt in 1977. The resource has since recovered and is now taken by both commercial and recreational fishermen in California and Mexico, and is probably fully utilized at present. The stock off the U.S. west coast has proven a problem to Canada when warming waters drive the fish north and the mackerel's habit of preying on salmon smolts makes it a nuisance species.

Jack mackerel stocks, on the other hand, represent an underutilized resource. Great concentrations of the fish are found off the west coast, extending well into international waters and, in some years, as far north as Alaska. Before the 1970s, when jack mackerel was placed under federal management, there were substantial foreign trawl fisheries for the resource, but the difficulty in locating large concentrations has inhibited development of a large domestic fishery. Small numbers are also taken incidentally by trawlers, particularly those targeting Pacific whiting, and at times jack mackerel is important to the Southern California partyboat fishery.

The most important Pacific pelagic species is Pacific herring, bringing fishermen up to $70 million a year. The west coast's herring fishery center is San Francisco, with a smaller fishery in Washington's Puget Sound. During World War I, herring were harvested for reduction to fish meal and for bait and pet food. More recently, herring roe has found a strong market for export as a Japanese delicacy. There is also a very lucrative roe-on-kelp fishery, which began in 1965 in California's Tomales and San Francisco Bays. Scuba divers originally cut the seaweed to which herring eggs had become attached. In the current fishery, however, giant kelp is harvested live from California's Channel Islands, brought to San Francisco Bay, and suspended from 60- by 40-foot floating rafts. The rafts are then towed to and anchored in areas where herring

BELOW: A modern gillnetter brings in a good haul of Pacific herring just off Los Angeles. © *Stephen L. Shapiro.* **TOP RIGHT:** At low tide in Kodiak Bay, Alaska, spent herring lie dead amid the seaweed on which they spawned. © *Allen M. Shimada.* **BOTTOM RIGHT:** Pacific herring are today more highly valued for roe than for the flesh. © *Stephen L. Shapiro*

ANNA HOPE
6375

are expected to spawn. After spawning, the kelp, with herring eggs attached, is removed from the rafts and packed in salt.

Pacific herring taken off Alaska, however, constitutes a much larger fishery than off California. It's the major pelagic species harvested and managed by the state, and comprises 20 separate herring fisheries. The resource is taken when the stocks come inshore to spawn in the Gulf of Alaska's Prince William Sound and Kodiak Island–Cook Inlet, and the Bering Sea's northern Bristol Bay and Norton Sound. The Gulf fishery is old, dating to the turn of the century, with catches peaking in 1936. Most of today's harvest consists of the roe-bearing females, but small amounts of food-and-bait whole herring and herring roe-on-kelp are also taken. Since part of the Bering Sea harvest is also taken incidentally in groundfish trawls, there is a cap on this bycatch.

Other Finfish

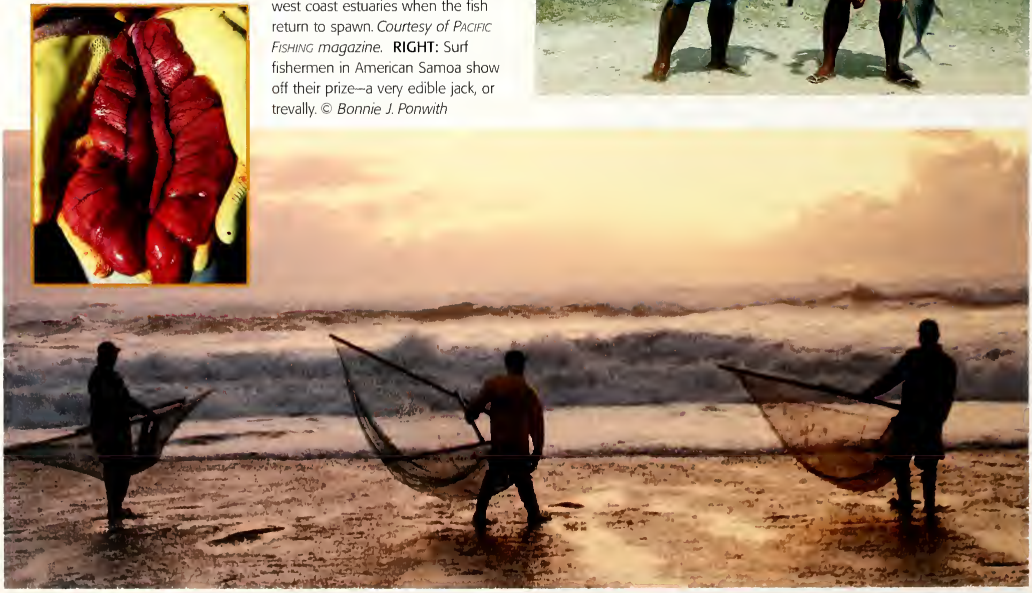
The west coast boasts many other finfish species, mostly nearshore and eagerly sought by small-scale fishermen. For example, small seasonal fisheries take smelt and silversides during migratory spawning runs to coastal areas and rivers. Some smelt fishing is almost a ritual, as with the nighttime smelt harvested by A-frame dip nets during their brief nocturnal spawning in the California and Oregon surf. The grunion—a tiny silversides—is the basis for a quite unique fishery, since harvesters may use only their hands to grab the slippery fish during the species' frantic spawning on Southern California beaches.

Many nearshore fish are especially important to the region's robust recreational fisheries: striped bass, sturgeon, shad, barracuda, croaker, sea bass, sheepshead, surf perch, yellowtail, turbot and sole, and California corbina. Some of these state-managed species have been reserved exclusively for recreation. And considering the more than $200 million dollars a year Californians alone spend on saltwater angling trips, it's understandable that coastal states have been persuaded to designate some resources as game fish.

The Western Pacific also harbors great assemblages of nearshore finfish. Some species support fisheries unique to certain localities, such as rabbitfish in Guam and limpet (*opihi*) in Hawaii. Other fisheries are common to all islands, such as for bigeye scad (called *akule* in Hawaii, *atule* in American Samoa, and *atulai* in Guam and the Northern Mariana Islands). The more populous main Hawaiian Islands receive the heaviest inshore fishing pressure, but even the uninhabited Northwestern Hawaiian Islands and the Northern Mariana Islands sometimes see significant catches. Two jack-like fishes, *akule* and *opelu*, support Hawaii's largest inshore fisheries, but there are also important local fisheries for surgeonfish, squirrelfish, parrotfish, goatfish, snapper, and various jacks or trevally.

Still other Pacific resources could be exploited, such as the strange-looking rattail and other deepsea finfish. The lack of reliable information on the size of such stocks and their role in the overall ecosystem makes their harvest problematic. There is also a rapidly expanding marine culture industry in the Pacific, especially

BELOW: Oregon beach fishermen ply their A-frame nets when the smelt come into the surf at twilight. © *Kris Freeman.* **LEFT, INSET:** Shad roe, prized in the east, is also taken in west coast estuaries when the fish return to spawn. *Courtesy of Pacific Fishing magazine.* **RIGHT:** Surf fishermen in American Samoa show off their prize—a very edible jack, or trevally. © *Bonnie J. Ponwith*



in the Western Pacific. Coral, clam, pearl oyster, shrimp, and many species of fish are successfully being farmed in ponds throughout Hawaii and the U.S. territories. Some of these are small, "mom-and-pop" operations. Other facilities run by universities and private research firms are introducing advanced technologies that permit large-scale operations and impressive profits by both American and overseas entrepreneurs.

Crustaceans

The west coast loves crab. King and Dungeness usually take top honors, with tanner and snow crab also commanding a following. A new entry, the Korean hair crab, is making impressive gains. Alaska's king, tanner, and snow crab alone bring fishermen $200–$300 million a year, and Dungeness, close to $80 million. Crab resources in the Western Pacific are quite small, however, although some small species, including land crab, are taken primarily for subsistence.

Until the mid-1980s North Pacific groundfish surge, a sparkling jewel in Alaska's fisheries crown was crab—specifically, the magnificent king crab. To gourmets everywhere, this long-limbed giant is still the royal. King crab fishing grounds are primarily in the Bering Sea and off Kodiak and the Aleutian Islands. Most of the animals are landed in Dutch Harbor and nearby ports, but some crabbing is also done off Southeast Alaska and in Prince William Sound. Until 1967, Japanese and Russian vessels dominated the Bering Sea crab fisheries, but by 1974 these had been phased out in favor of an American fleet. In the Gulf of Alaska, depletion of king crab stocks has led to an almost total closure of this fishery since 1983.

King crab resources (three species—red, blue, and golden) have also dwindled elsewhere, but they still bring fishermen $40–$60 million a year. The directed catch is taken almost exclusively in baited pots by crabbers from all over the Pacific Coast, but a great many adult and juvenile king crab are also taken as bycatch in groundfish trawls. Much of this bycatch is dead or heavily damaged, and this mortality must be accounted for in setting harvest quotas for the crab fisheries if the stocks are to be maintained. Understandably, crab fishers—a fleet of 350–400 vessels—are eager to constrain or eliminate this bycatch portion of the resource they depend on.

As king crab stocks have declined—suspected culprits include heavy harvesting, parasites, predators, and natural environmental conditions—tanner crab catches have increased dramatically. Two species are taken commercially, one commonly called *bairdi*, and the other, *opilio*, also known as snow crab. For both species, abundance is highly variable, with landings and

TOP LEFT: Lost gear has at least one benefit: juvenile tanner crab use the nets for protective habitat. © *Allen M. Shimada.* **INSET:** Plummeting king crab stocks have allowed tanner and snow crab to find a permanent market niche. © *William B. Folsom Photography, Inc.* **BOTTOM LEFT:** Fishing may be brutal, but a season of good crab catches can bring the vessel a million dollars or more. © *Mandy Merklein.* **BELOW:** King crab being unloaded at Dutch Harbor, Alaska, promises good profits for hardy North Pacific fishermen. © *Brad Matsen*

DUNGENESS CRAB

LEFT: Cooked Dungeness crab is a big draw at displays like this one at Seattle's famed Pike Place Market. *William B. Folsom, NOAA Fisheries.* **ABOVE:** Garibaldi is only one of many coastal Oregon towns that support the sizable fleet of Dungeness crabbers. © *Index Stock/Mark Gibson*

value often swinging from year to year. For example, crabbers earned more than $200 million from tanner and snow crab in 1995, but less than half that in 1996. Tanner crab is considered somewhat overfished, while snow crab, with much larger populations, is not. The status of the Korean hair crab, currently taken in much smaller quantities, is uncertain.

Most of the large crab boats—and some, especially the factory ships that freeze or can the cooked crab, are immense—have observers on board to record the catch. Crab resources are managed cooperatively by Alaska and the federal government, with catches restricted by quotas, seasons, and size and sex limits (only large male crabs may be landed).

Unlike the king and tanner crab fisheries, which generally take place in deeper North Pacific waters, the shorter-legged Dungeness crab is taken in commercial quantities from Central California to Alaska, and from bays to the open ocean. This is the famed "walking crab cocktail" of San Francisco's Fishermen's Wharf, and that city and Eureka have long been California's Dungeness centers. Washington, Oregon, and Alaska also have substantial Dungeness landings, with almost the entire product consumed domestically. Dungeness, also fished heavily by Canadian fishermen, is subject to wide natural fluctuations, and its distribution also varies greatly. The animals sometimes move into very deep water or migrate into northern waters, making them inaccessible to the fleet's smaller boats.

Most Dungeness is taken in pots or traps, and individual boats can tend a thousand or more pots. Many crabbers have also traditionally fished for salmon in the off season and when crab catches are poor, and the drastic decline of Pacific Northwest salmon has added considerably to their woes. Dungeness crab is considered somewhat overfished, and management is by the individual states.

Several species of coldwater shrimp are taken along the Pacific Coast, abundant from Central California to the Bering Sea. By far the largest state landings are in Oregon. The most commonly harvested

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NEAR RIGHT: Some seafood restaurants, like this one in Newport Beach, California, specialize in Dungeness, king, and snow crab. **FAR RIGHT:** Seattle's Pike Place Market offers up cooked coldwater shrimp from Pacific waters. *Photos by William B. Folsom, NOAA Fisheries* species are the northern "pink" shrimp (quite distinct from the large pink shrimp taken off southern Florida), Pacific Ocean, spot, side-stripe, and bay shrimp. Combined Pacific shrimp landings, although dwarfed by the Southeast's shrimp harvest, still bring fishermen a respectable $25 million or more a year, and the delicately flavored shellfish is highly valued by gourmets. In addition, there is a substantial recreational shrimp fishery, especially near such urban centers as Puget Sound. Trawls are the primary gear, although highly specialized traps are also sometimes used. Shrimp resources are managed by the individual states, and those of California, Oregon, and Washington are considered fully utilized. In Alaska, though, shrimp stocks are currently at very low levels as a result of several decades of heavy fishing off Kodiak and along the Alaska Peninsula.

Although Pacific spiny lobster harvests are much smaller than the shrimp harvests, they're important in some communities. Unlike the larger New England species, the spiny lobster lacks the giant claws that provide both a succulent dining bonus and grievous wounds to comrades in the lobster tank. A small amount of spiny lobster is taken by sport divers in California (and much more along Mexico's Pacific Coast), but America's Pacific lobster fishery is centered in the uninhabited Northwestern Hawaiian Islands. Both spiny and slipper lobster are taken in Hawaii by commercial vessels carrying 800–1,000 traps. Though the federally managed, limited-entry lobster fishery in Hawaii is relatively young, dating only to 1977, the high price for frozen lobster tails spurred a rapid development of this fishery.

The Northwestern Hawaiian Islands lobster stocks appear to be particularly vulnerable to natural, decade-long declines as a result of ocean conditions that affect recruitment and, thus, the economic stability of the fishery. Federal regulation of the fishery is relatively strict—annual catch quotas, mandatory use of escape vents on traps, and limited entry. Because lobster is a high-value product taken by a small number of vessels, the industry has begun to proactively control effort, scheduling fishing times and maximizing the value of the catch by encouraging export of the live animals.

Hawaiian spiny lobster is prized, but seldom appears outside local markets.
© William B. Folsom Photography, Inc.

Chant of Kuali, the Ancient Hawaiian Fisherman

Oh, the great fishhook of Maui!
Manai-i-ka-lani—"made fast to the heavens"!
An earth-twisted cord ties the hook,
Engulfed from lofty Kauiki!
Its bait the red-billed Alae,
The bird to Hina sacred!
It sinks far down to Hawaii,
Struggling and in pain dying!
Caught is the land beneath the water,
Floated up, up to the surface,
But Hina hid a wing of the bird
And broke the land beneath the water!
Below was the bait snatched away
And eaten at once by the fishes,
The Ulua of the deep muddy places!

–Jack London, *The Water Baby*, 1918

Molluscs

A surprising number of molluscs is harvested on the west coast, and many are taken in sizable quantities. Mirroring Atlantic harvests, the most important species are oyster, squid, and scallop, but other, rather exotic and high-value resources are also fished: octopus, geoduck and other clams, and abalone. The Western Pacific offers much more modest mollusc resources, although Guam harvests squid, octopus, cuttlefish, tridacna clam, conch, chiton, and other species.

Oyster is among the best-known Pacific molluscs, with sizable markets for fresh shucked and in-the-shell product, but also for canned and smoked. Early coastal tribes treasured the plump tideland gems, and settlers from the East were delighted to find on the Pacific a counterpart to their treasured Virginia oyster. In fact, oyster dominates the nation's marine culture industry, followed by clam, mussel, and shrimp.

Two species constitute most of the harvest in Washington and California—the native (Olympia) oyster and the larger Pacific oyster, which was introduced in the 1920s from Japan and is the dominant species cultured today. There are many varieties of this oyster, each with a distinct flavor (so say the connoisseurs). Until World War II, the industry in Northern California—Humboldt, Tomales, and Morro Bays—used oyster seed imported from Japan, but oystermen there today, as in Washington, use hatchery-raised seed-oyster. The molluscs are grown in nearshore leased or privately owned beds after the oyster spat has adhered to a layer of shells. They're harvested at low tide by hand, or at high tide by dredges and tongs.

Most of this oyster resource is in Washington. The Pacific harvest constitutes about a quarter of the nation's total oys-

LOCAL WASHINGTON CRAB
5.99

TEAM NUMB
17

LEFT: Seafood markets feature the surprising variety of oysters that have helped make Seattle a seafood paradise. **ABOVE:** Fans at Seattle's annual Oyster Olympics celebrate Puget Sound's flourishing oyster industry. **RIGHT:** A contestant mans the oyster knife for a round of "speed shucking" at Seattle's annual Oyster Olympics. *Photos by William B. Folsom, NOAA Fisheries*

ter production (the Gulf of Mexico yields about 57 percent and New England, about 11 percent, for a combined U.S. value to harvesters of more than $110 million a year). Oyster resources are generally healthy now, although they were devastated for decades by widespread pollution from local industry, domestic sewage, and freshwater runoff, as well as by disease, parasites, and predation by sharks, skates, and other nearshore oyster-crushers. Strict enforcement of the 1972 Clean Water Act, especially in Washington's Puget Sound, has brought about an amazing transformation. A feast of oyster varieties now graces the market, an accomplishment celebrated exuberantly in the samplings, shucking contests, and other events of Seattle's famed annual Oyster Olympics.

Another resource, growing in popularity but still viewed a bit queasily by some, is the California market squid. The mollusc is much savored as calamari in traditional southern European cuisine and has long had a solid Asian market, but squid dishes in America have lacked the appeal of grilled lobster or a seared tuna steak. Nevertheless, the strange little creatures have managed to become the basis of California's most valuable fishery, with recent catches bringing the state's fishermen over $20 million a year—more than twice what the famous chinook salmon brings.

The squid fishery has seen most of its growth in the last decade, at least in part because other coastal fisheries have diminished, but also in response to growing acceptance of squid as a healthful delicacy. The squid fleet, which consists of seiners from everywhere on the Pacific Coast, including Alaska, tends also to fish for California's "wetfish" resources—sardine, anchovy, and mackerel—and a growing number of boats are also taking coastal tuna.

Like pelagic finfish, the squid resource is notorious for its variability, with harvests see-sawing wildly between 40,000 and 80,000 tons in recent years. Almost always, however, Pacific squid harvests are greater than those on the east coast. Most of the harvest is taken in winter, when the spawning squid are found near the coast, especially around California's Channel Islands. In strong El Niño years, however, catches are extremely low, probably more as a result of the animals' retreat to cold, deep waters than to any die-off caused by

Much handsomer alive than as market product, the squid is catching on rapidly in the restaurant trade. © *Brandon D. Cole.* **INSET:** Long a staple of European and Asian cuisine, squid is now showing up in more traditional American cookery. © *William B. Folsom Photography, Inc.*

the warm surface waters inshore. Squid are often lumped with the pelagic finfish species for management purposes, but in fact, this fishery isn't regulated. That may change with increasing domestic and foreign market demand for the resource, with California likely to develop measures to control access to this booming fishery.

Another west coast mollusc resource, clam, has never quite had the cachet enjoyed by its cousins on the Atlantic seaboard—although the hefty Pismo clam has its loyal following, and a comical mystique surrounds the legendary geoduck (strangely pronounced "gooey-duck"). In fact, more than 35 species of edible clam are found in the region, all of which are managed by the states. Only a few of them, such as razor clam and geoduck, are commercially fished. But for those few species, about one million pounds of meat are harvested annually, with recreational diggers on Washington's sandy beaches taking most of the catch. During spring and summer, beachgoers of all ages crowd the Washington and Oregon shoreline at low tide to dig for their limit of razor clam. This softshell species, which is actually more abundant in Alaska, is quite tasty but often leaves inexperienced clammers with empty buckets as a result of its burrowing talent.

The clam world's hands-down escape artist, though, is the extraordinary Pacific geoduck, a gigantic and long-lived creature especially desired for the Chinese market and harvested primarily in Washington's Puget Sound. Once touted mainly as a test of man-versus-clam digging skill, this rubbery beast with a long neck up to 4 feet now commands around $100 a serving in fine Asian restaurants. Commercial geoduck divers use high-pressure jets to excavate the clam, but the animals, managed under strict state regulations, are also taken by recreational divers and beachcombers.

Other clam species are harvested too, although not nearly in the amounts taken on the east coast or produced by the aquaculture industry. Both commercial and recreational harvesters take hard clam (the native littleneck, horse clam, butter clam, and cockle) and a regional favorite, the Manila clam, introduced decades ago from Japan. These are clams dug with shovels, rakes, or forks on beaches exposed at low tide, but there are also substantial unharvested hard clam resources in deeper offshore waters.

Hindering exploitation of some stocks, however, has been the historic problem of paralytic shellfish poisoning that occurs in some Pacific waters; an economic method of identifying and detoxifying infected molluscs could mean considerable revenue gains from this resource. Harvests are regulated by states through seasonal closures and bag limits, but because so many separate stocks occur on so many beaches, the status of clam stocks and degree of utilization are largely unknown.

Scallop, another Pacific mollusc treasure, is primarily harvested in Alaska, with weathervane scallop the primary species. Pioneered in 1967, the industry's main harvest areas have been Kodiak and Yakutat in

MIDNIGHT
HOUR

Vessels in Ventura, California, target several fish species, as well as squid and other invertebrates. *William B. Folsom, NOAA Fisheries*

ABOVE: Littleneck clams and a dollop of drawn butter: an ambrosia worthy of Neptune. © *William B. Folsom Photography, Inc.* **RIGHT:** Manila clam, a Northwest delicacy, can sometimes be found in Seattle seafood stores. *William B. Folsom, NOAA Fisheries*

the Gulf of Alaska, but in recent years, the Bering Sea area near Dutch Harbor has emerged as a new fishing ground. Harvesting is by the same dredging gear and techniques used in the New England and mid-Atlantic scallop fisheries. In fact, the depletion of Atlantic clam stocks has seen some east coast vessels moving into Alaska to exploit its offshore scallop beds. The status of the resource, managed by Alaska through license limits and catch quotas, is not well known, but landings have declined in recent years, and the animals are believed to be vulnerable to overfishing.

Sea snail comprises still another mollusc harvest. There is a very modest take of the animals off Alaska, although from 1971 to 1987, the resource supported a much larger take by Japanese fishing U.S. waters in the Bering Sea. Alaska snail stocks are today underutilized because they're only lightly harvested, with just a few vessels active in the fishery. Another Pacific snail, a limpet (*opihi*), has become depleted in Hawaii, where it is especially prized.

Without a doubt, however, the most prized Pacific Coast mollusc is the abalone, which commands extraordinary prices both as fresh "steaks" and as canned product (a 14-ounce can of abalone may retail for $50 in Seattle's Chinatown). California waters produce most of the five-species harvest, with red abalone dominant, followed by green and black abalone. In Alaska, where indigenous people have a long history of harvesting abalone for food, shell ornaments, and trade, the principal species in this relatively new commercial fishery is pinto abalone, taken almost exclusively in the state's Southeast and destined mostly for Japan's discriminating gourmets.

Abalone is taken commercially by hooka gear, compressed air from the surface supplied by hose to divers. Recreational catches are taken by both scuba-equipped and free-diving pickers (scuba is illegal in many areas because this method can so rapidly decimate an area). Abalone diving is hardly new to California, though. It was introduced by Japanese immigrants in 1900 when the intense gathering of intertidal abalone by Chinese fishermen wielding hooked poles became unlawful.

LEFT: A crewman aboard a west coast oyster boat prepares to lower the heavy dredge used for harvesting submerged beds. © *Brad Matsen.* **BELOW:** The discovery of large beds off Alaska have helped maintain domestic supplies of sea scallop. © *William B. Folsom Photography, Inc.* **RIGHT:** Treasured for its meat as well as its shell, abalone is a prime candidate for aquaculture on the Pacific coast. © *William B. Folsom Photography, Inc.*

Managed by the states, abalone are overutilized as a result of strong market demand, their popularity to sport divers, and declines resulting from habitat degradation, sea otter predation, and disease, such as the withering syndrome responsible for an especially heavy recent mortality of black abalone. Nevertheless, California's abalone aquaculture industry is steadily growing, with more than 20 such farms currently in operation. In 1995, for the first time, more cultured than wild product was harvested, primarily the large red abalone. Most U.S. farmed abalone, now available year-round, goes to Asia, where the premium grade brings growers almost $18 a pound in Japan.

Other Harvests

There are still other, more novel, seafoods finding their way onto the expanding Pacific buffet table: sea urchin, sea cucumber, cuttlefish, topshell, conch, kelp, and even a large Western Pacific worm. The harvest of sea urchin, especially, has seen a dramatic rise in recent years, with increased demand for the delicately flavored red-urchin roe in sushi. California's take of the spiny animals accounts for about 90 percent of the region's urchin harvest, although there are also small fisheries in Washington, Oregon, and Alaska. California's commercial fishery began modestly in 1971, but in 1995 brought fishermen more than $25 million. Harvesting urchins requires only a modest investment—very small boats with a two-man crew, an onboard compressor, diving equipment, and collecting baskets. Divers use either hooka or scuba gear and land the animals alive. Most of the product destined for shipment to Japan is sent as roe, but much of Alaska's catch is now shipped alive.

Managed by the states, some local stocks of urchin have been overfished, and the California resource in particular has been proposed for individual quotas as a means of stabilizing markets and preventing depletion. Another, perhaps more vexing, problem also jeopardizes urchin yields. The warm waters associated with El Niños are believed to inhibit the growth of the urchins' primary foodstuff, kelp, and in turn, potentially decrease both the size and the number of harvestable urchins.

The lumpy sea cucumber, also called *bêche-de-mer* or *trepang*, is another recent, if modest, entry in the California seafood market, with commercial harvests beginning in the late 1970s; some sea cucumber is also harvested in Alaska. Long valued in Asian cuisine, this creature is harvested primarily by trawl, and generally processed into a dried product, although it also turns up as whole frozen animals. Two quite distinct species are taken in California—the giant red sea cucumber and the warty sea cucumber. Little is known of their abundance or stock status, and as relatively few are currently taken, the resource doesn't appear to be threatened at this time.

Among the many localized industries for marine animals are the small fisheries for sea worm. Along the Pacific Coast, small amounts of sand- or mud-burrowing segmented worms (and other kinds) are harvested for fish bait. In American Samoa, there is a different use for one species, the *palolo* worm. This is a large segmented worm captured in nearshore reef areas at predictable periods of emergence. The animals are quite large, and certain of the worms' segments, or epitokes, are enjoyed as a great delicacy.

As for seaweed, the main resource is California's kelp, a brown alga that can grow a foot or more each day. First harvested in 1910 as a source of potash, iodine, and acetone (for explosives), kelp was later collected as food for livestock, and especially for the hundreds of household and industrial products requiring a

RIGHT: The only edible portion of the urchin is the delicate orange roe, a favorite on the sushi circuit. *William B. Folsom, NOAA Fisheries.* **BELOW:** Long overlooked as food, California's red urchin is now eagerly sought by hordes of sushi and sashimi lovers. © *Brandon D. Cole*

LEFT: When the conditions in Samoa are right for gathering palolo worms, the locals are ready … and eager. **RIGHT:** Palolo worms–a rare and delicate Samoan treat, but not to everyone's taste. *Photos © Bonnie J. Ponwith*

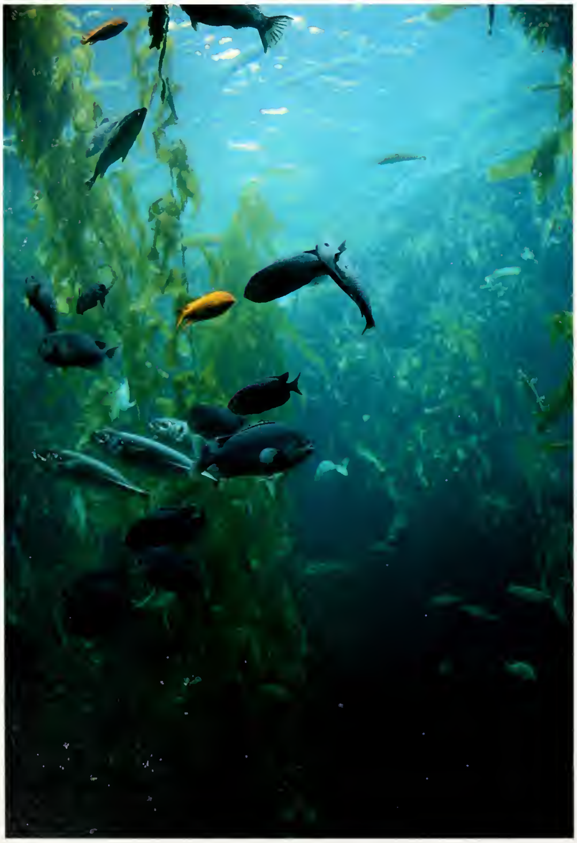
binding or homogenizing agent—jelly- or pudding-like desserts, ice cream, salad dressing, toothpaste, cosmetics, rubber, paint, and adhesives. The primary colloidal substance is algin, derived from the giant kelp growing in nearshore waters and harvested by large cutter barges. Most kelp isn't suitable for the "sea greens" now popular in Asian cuisines. Better resources are the east coast's Irish moss and the flat seaweeds (*nori, wakame,* and *hijiki*) harvested elsewhere in the world. There are also strong markets for ground kelp and other west coast seaweeds in pharmacological products and health compounds.

Kelp resources are managed by the state, but they haven't always enjoyed their currently healthy condition. During the 1960s and 1970s, kelp plants were decimated by an inundation of sea urchins feeding voraciously on the young plants. Research revealed that urchins, which normally migrate elsewhere after reducing kelp density in an area, were staying put, feeding on the trash and sewage emptied directly into nearshore waters. When the tiny kelp plants tried to establish the root-like "holdfast" on the sea floor, the resident urchins made short order of them. Eliminating the urban waste discharge has restored the kelp forests, permitting a healthy balance of both seaweed, which harbors a great many highly valued recreational fish, and urchin, which themselves now comprise an estimable harvest.

PROTECTED SPECIES

Even after the devastating whale and seal hunts of the 19th century, the nation's Pacific waters still harbor a great wealth of marine mammals. Alaska alone has 25 species—seals, sea lions, walrus, whales, dolphins, sea otter, and polar bear. But the west coast and Western Pacific have an even more diverse marine mammal fauna, boasting 37 species. Pacific seabirds were also once hunted intensively for their eggs: birds nesting in the Farallone Islands were decimated in the 19th century to feed the hordes emigrating to work California's gold fields.

Many protected species, however, remain endangered or threatened long after the prohibition on commercial harvests. Hunted for fur, ivory, whalebone, blubber, and meat, marine mammals—and not fish—were a major



California's kelp forests harbor an immense wealth of nearshore fish that attract fishermen and scuba divers. *William B. Folsom, NOAA Fisheries*

Watching killer whales provides welcome entertainment during long days of fishing off the Northwest and Alaska. © *Mandy Merklein*

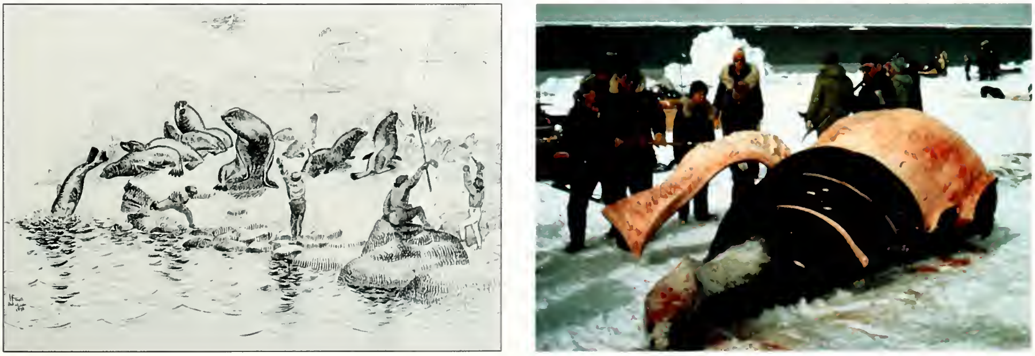
factor in the exploration and development of Alaska, the Pacific Northwest, and Hawaii. Nineteenth-century whalers from many nations profited from the abundant but rapidly declining whale stocks—blue, sperm, humpback, gray, fin, bowhead, and northern right—all of them found throughout the Pacific. In fact, Hawaii's prominence came about largely as a result of the Islands' importance in provisioning the era's great fleets of whaling ships.

Large-scale sealing by Americans began even earlier than whaling, about 1790. Hunting started in the South Atlantic, then moved to the massive rookeries in the Bering Sea and Gulf of Alaska as Antarctic fur seal populations diminished. By the end of the 19th century, stocks of fur seal, sea lion, sea otter, walrus, and Steller sea cow (now extinct) had been utterly decimated, with millions of pelts and thousands of tons of tusks loaded aboard Russian, American, and British frigates and shipped around the globe. Some species, such as Steller sea cow, were used to feed the masses of immigrants to Alaska.

Although all U.S. marine mammals and sea turtles are protected today, a handcraft and subsistence take is permitted among some indigenous Alaskans for bowhead and beluga whales, seals and fur seal, and walrus. Some Northwest tribes also have treaty rights that permit harvesting of California sea lion and harbor seal. These hunts, strictly regulated and monitored by the government, are given a grudging nod of approval by the wider American society on the basis of tribal tradition. Very recently, courts have determined that some tribes, such as the Pacific Northwest Makah, should be allowed to resume their historic hunts of the now-recovered gray whale. Not surprisingly, this proposed take that is far more visible to the nation has generated anger among some conservationists who insist that no whaling be permitted anywhere.

A similar history befell Pacific sea turtles. Until recently, they were hunted mercilessly for their shell, meat, and eggs, and all species today are listed as either endangered or threatened under the Endangered Species Act, although green sea turtle appears to be recovering. In Hawaiian

LEFT: Steller sea lion was only one of several Pribiloff Islands, Alaska, mammals hunted in the 18th and 19th centuries. *Drawing by H.W. Elliott, The Fisheries and Fishery Industries of the United States, NOAA Fisheries.* **RIGHT:** A bowhead whale taken in an authorized Alaska indigenous hunt is distributed to villagers. *Courtesy of Gene Cope, NOAA Fisheries*



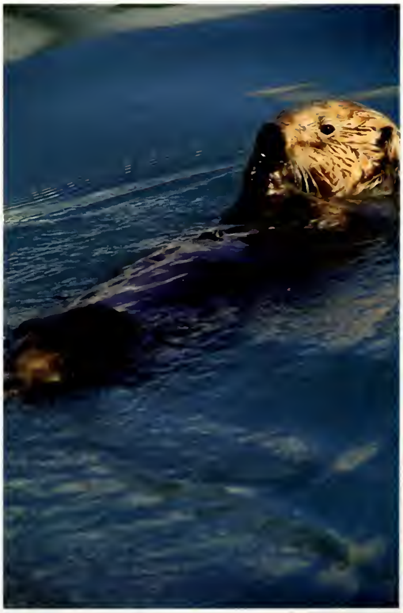
The population of green turtles around Hawaii may be suffering as a result of accidental capture on longlines. *George Balazs, NOAA Fisheries*

waters, especially, hawksbill turtle was once common and may still be found. The incidental capture of leatherback, loggerhead, and olive ridley in the Northwestern Hawaiian Islands swordfish and tuna longline fisheries remains problematic, and federal observers carefully monitor catches. The use of controls on Hawaii longliners to limit turtle takes remains contentious. As fishermen point out, bycatch reduction won't by itself solve the declining world turtle populations because of these wide-ranging animals' decimation at the hands of other nations. Along the continental Pacific Coast, loggerhead, leatherback, and olive ridley turtles are occasionally seen and are sometimes taken in drift gillnets. Nearshore and reef gillnets in Hawaii, and propeller strikes and vessel collisions almost everywhere, also pose threats to these slow-moving animals.

While some potential remains for losing marine mammals, the Pacific has seen some amazing recoveries as a result of stringent conservation programs. The Pacific gray whale, after suffering devastating reductions, has rebuilt to the point where it was removed in 1994 from the Endangered Species list. Walrus populations have more than quadrupled in recent years to over 300,000 animals. And California sea lion are now so abundant that mobs of the huge animals occasionally sink the anchored boats they use for their nightly "haul-outs," and the species has become a major source of damage to coastal fishing nets.

BELOW: Whale watching is big business in Alaska's Prince William Sound. **RIGHT:** The American public has decreed that the charming sea otter get a fair share of Neptune's Pacific bounty. *Photos © William B. Folsom Photography, Inc.*

KLONDIKE
KLONDIKE
KLONDIKE



Just off Honolulu, whale-watch boats loaded with eager tourists head for the NOAA Humpback Whale Sanctuary. *Dennis M. Weidner, NOAA Fisheries*

In yet another clash between fishers and fur-bearers (and this must be the world's most losing public relations battle), west coast fisheries have long been ardent foes of that ultimate charmer of the wild kingdom, the sea otter. Populations of the fetching little animals, whose exquisite pelt became the standard by which all fur-bearers are still judged, were drastically reduced by centuries of relentless hunting. More recently, sea otter suffered at the hands of some fishermen convinced that the dexterous animals were serious competitors for abalone, oyster, and sea urchin. But ardent environmentalism, along with the animals' world-class cuteness, has triumphed, and today the sea otter enjoys near-icon status in the eyes and on the T-shirts of millions of Americans.

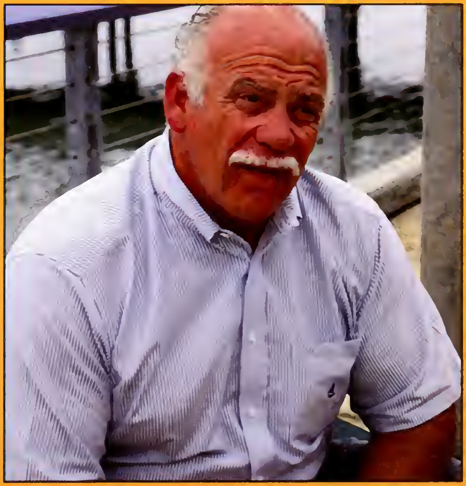
If the hunts for protected species have for the most part ended, in accordance with the wishes of the American people, conserving these stocks has given rise to a new industry in the Pacific, as it has on the eastern seaboard: whale watching. Seemingly everywhere along the Pacific Coast and in Alaska's magnificent sounds and bays, commercial fleets have sprung up to accommodate the hundreds of thousands of citizens and foreign visitors bent on getting close to the behemoths. California alone has such boats in almost every port from San Diego to Eureka, offering paying passengers gratifying—if brief—treks alongside gray whales migrating with their calves from Alaskan waters to the calving grounds off Baja California. In more northern waters and off Hawaii, hundreds of cruise ships and charter boats attract well-paying passengers by offering up an often-thrilling proximity to gamboling humpback whales, killer whales, or other species.

Big Business SPORTFISHING

Tony LoPresto, perhaps more than anyone on the west coast, represents the face of large-scale sportfishing. Over the years, thousands upon thousands of customers have gotten their money's worth aboard Tony's San Diego-based partyboats fishing the waters off California in search of tuna, yellowtail, billfish, and other species. Like partyboats everywhere, these roomy vessels are crammed with state-of-the-art navigation devices and fish-finders, safety gear, electric reels for deepwater fishing, and a crew focused on providing their paying customers with a top-flight experience. The competition everywhere is heavy, though, not only from similar head boat or partyboat operations, but from the many smaller charter boats working coastlines everywhere in the nation. It's not unusual for a well-heeled customer to fish in Hawaii, California, Florida, and Puerto Rico, all in one year.

Party- and head boat operations are indeed big business and can require a very considerable capital investment for labor, equipment, supplies, and administration. In addition, entrepreneurs wishing to fish in the waters of neighboring countries—Mexico, Canada, the Caribbean, and elsewhere—must possess great patience and negotiating skills to navigate the maze of political and administrative requirements. But the payoff for shouldering big-business burdens can be substantial if good catches result. And since partyboats tend to depend on repeat business, good catches translate into return customers.

Tony LoPresto, San Diego, California (William B. Folsom, NOAA Fisheries)



Do these ventures constitute a "fishery"? Not in the traditional—and appropriate—sense. As with non-take scuba diving and snorkeling and glass-bottom boat "fish watching," these alternative "uses" of America's living marine resources constitute economic and social benefits to coastal communities, blessings fully consistent with Neptune's bounteous table.

A FINAL LOOK AT THE PACIFIC

Pacific America shares some of the Atlantic's fisheries problems—bycatch, overcapitalization, and habitat loss. But this diverse region stretching from Alaska to California and across the ocean to Hawaii and the Western Pacific territories is very different. This is the domain of the freezer-trawler and factory ship, the sleek tuna clipper and the million-dollar charter boat. It is also a region where indigenous groups, especially Alaska and Northwest Native Americans, have become a major force in the allocation of fisheries resources.

Most U.S. Pacific fisheries are healthy and productive, although warming climate conditions and El Niños have seen a greater impact here than on the Atlantic Coast. There are still some untapped Pacific resources, although not for high-value species. A few resources show signs of unsustainable fishing pressure, and some west coast salmon runs may disappear as a result of industrial development and river management practices.

In the 19th century, modest dory fisheries for salmon and herring supported migrant miners; today, the vast groundfish resources sup-

Neptune's kingdom. © *William B. Folsom Photography, Inc.*

With care, Pacific coastal streams can continue producing a share of the region's fisheries wealth. *Joni Packard, NOAA Fisheries*

port the nation's largest and most technologically advanced fleets. Although much of this output is for the homely fish paste used to make surimi, Pacific fisheries also supply a great abundance of luxury seafoods—crab, sole, salmon, and tuna.

Especially in California, the Northwest, and Hawaii, the recreational fishing sector has become a powerful political force. Thousands upon thousands of recreational boats dot the ocean throughout the year, and beaches and piers are crowded with pole fishermen. Alaska, on the other hand, sees far fewer anglers, mostly nearshore salmon fishermen. But like their Atlantic counterparts, both commercial and recreational Pacific fisheries are likely to continue as vital threads in the American social fabric.

PLEASE
KEEP OUT
FISH CLEANING
SERVICE

7

AFTERWORD

This book's 1971 predecessor, *Our Changing Fisheries,* concluded with predictions for fisheries by the year 2000. Some were fanciful, others lofty, and many prescient. The experts predicted intensive aquaculture development, sophisticated new navigation and fish-finding technologies, and exploitation of untapped stocks. They foresaw international product standards, new ways to expand the shelf life of fish and shellfish, and bold seafood marketing and distribution networks. All these have come about.

There were other important visions. The authors advocated uniform management practices among federal and state agencies and called for removing barriers to commercial fisheries growth. But they cautioned that these must be consistent with the requirements of other groups using the seas. Most important, perhaps, they identified unregulated competition—both domestic and international—and destruction of the environment as the most pressing problems to solve, and concluded that so long as the open access concept persists, excessive capital and labor in a fishery would also exist.

The experts sometimes missed the mark, though. They anticipated far greater use of fish meal and fish protein concentrate for both animals and humans, commercial processing of plankton for the dining room, and widespread use of fish-attraction devices. They overlooked sea safety issues—the heavy loss of life—that would later lead to laws adding greatly to operating costs. Although pollution was decried, there was no understanding of its real impact on fisheries productivity for wetland loss.

Most notably, no one foresaw the phenomenal growth of recreational fisheries and environmentalism, and their impact on commercial fishermen—a management era where interests other than commercial fishermen or the government had major roles in regulation. And *Our Changing Fisheries'* authors assumed that the problems they had identified would be addressed—and solved—by the year 2000, a vastly over-optimistic prophecy.

Heeding the past, then, *Neptune's Table* makes no prediction when the loss and degradation of essential fisheries habitat will cease, or even diminish substantially, or when fisheries bycatch will be sufficiently reduced. There are no projected time frames for the full recovery of overfished stocks, substantial reduction of excess fisheries capital and labor, or scientists' ability to accurately predict the effects of changing ocean conditions on fishery resources or the fisheries that depend on them. There is only the hope, amidst an enlightened spirit of cooperation, that these goals will be reached.

FACING PAGE: Every last bite. © *William B. Folsom, NOAA Fisheries*

Glossary of Frequently Used Terms

Allocation Distribution of the opportunity to fish among user groups or individuals. The share a user group gets is sometimes based on historic harvest amounts.

Anadromous Referring to fish that migrate from salt water to fresh water to spawn.

Angler A person catching fish or shellfish with no intent to sell; a recreational fisherman. This term includes people releasing the catch.

Aquaculture The raising of fish or shellfish under some controls. Ponds, pens, tanks, or other containers may be used. Feed is often used. A hatchery is also aquaculture, but the fish are released before the harvest size is reached.

Artisanal Fishery Commercial fishing using traditional or small-scale gear and boats.

Availability Describes whether a certain kind of fish of a certain size can be caught by a type of gear in an area.

Bag Limit The number and/or size of a species that a person may legally take in a day or trip. This may or may not be the same as a possession limit.

Benthic Refers to animals and fish that live on or in the bottom of a water body.

Biomass The total weight or volume of a species in a given area.

Bycatch The harvest of fish or shellfish other than the species for which the fishing gear was set. Examples are blue crabs caught in a shrimp trawl or sharks caught on a tuna longline. Bycatch is also often called incidental catch. Some bycatch is kept for sale.

Bycatch Reduction Device (BRD) Any of a number of implements that have been certified to reduce the likelihood of capturing nontarget species.

Catadromous Referring to fish that migrate from fresh water to salt water to spawn.

Catch The total number or poundage of fish captured from an area over some period of time. This includes fish that are caught but released or discarded instead of being landed. The catch may take place in an area different from where the fish are landed. Note that catch, harvest, and landings are different terms with different definitions.

Charter Boat A boat available for hire, normally by a group of people for a short period of time. A charter boat is usually hired by anglers.

Commercial Fishery A term related to the whole process of catching and marketing fish and shellfish for sale. It refers to and includes fisheries resources, fishermen, and related businesses directly or indirectly involved in harvesting, processing, or sales.

Common-Property Resource A term that indicates a resource owned by the public. For example, it can be fish in public waters, trees on public land, and the air. The government regulates the use of a common-property resource to ensure its future benefits.

Controlled Access Also called limited access and limited entry. A program that restricts the persons or vessels that may participate in a fishery. License limitation and individual fishing quota programs are two forms of controlled access.

Council Refers to one of the eight Regional Fishery Management Councils authorized under the Magnuson–Stevens Fishery Conservation and Management Act to develop federal fishery policies and procedures.

Crustacean A group of freshwater and saltwater animals having no backbone, with jointed legs and a hard shell made of chitin. Includes shrimp, crabs, lobsters, and crayfish.

Demersal Fish and animals that live near the bottom of a water body.

Derby Fishery Generally, a fishery operated under conditions where each vessel has an incentive to catch the greatest number of fish in the least amount of time.

Directed Fishery Fishing that is directed at a certain species or group of species. This applies to both recreational and commercial fishing.

Ecosystem An ecological community considered together with the nonliving factors of the environment as a unit—for example, a coral reef ecosystem.

Effort The amount of time and fishing power used to harvest fish. Fishing power includes gear size, boat size, and horsepower.

El Niño A cyclic weather phenomenon occurring every few years that affects climate and water temperature around the globe.

Endangered Species A species is considered "endangered" under the Endangered Species Act if it is in danger of extinction throughout a significant portion of its range; it is considered "threatened" if it is likely to become an endangered species.

Escapement The percentage of fish in a particular fishery that escape from an inshore habitat and move offshore, where they eventually spawn.

Exclusive Economic Zone (EEZ) All waters from the seaward boundary of coastal states out to 200 nautical miles. This was formerly called the Fishery Conservation Zone.

Ex-vessel Value The amount paid to a vessel's owner or operator for its catch, excluding any value added by at-sea processing.

Fish Kill A mass mortality of fish or shellfish resulting from abnormal natural or human-induced environmental conditions, or the release of dead fish taken in a fishing operation.

Fishery All the activities involved in catching a species of fish or group of species.

Fishery-Dependent Data Data collected on a fish or fishery from recreational fishermen, commercial fishermen, and seafood dealers.

Fishery-Independent Data Data collected on fish by scientists who catch the fish themselves, rather than depending on data taken from fishermen and seafood dealers.

Fishery Management Council See Council.

Fishery Management Plan (FMP) A plan to achieve specified management goals for a fishery, including data, analyses, and management measures.

Fully Utilized The level of utilization where fishing effort will support the achievement of long-term potential yield.

Game fish Specific fish made a legal catch for recreational fishermen by legislation; sometimes the species may be taken only by anglers.

Ghost Fishing The capture of fish or other living marine resources by lost or discarded fishing gear.

Groundfish A species or group of fish that lives most of its life on or near the sea bottom; sometimes called bottomfish.

Harvest The total number or poundage of fish caught and kept from an area over a period of time.

Haulback The period in fishing operations during which the gear is hauled from the water back onto the fishing vessel.

Head Boat A fishing boat that takes recreational fishermen out for a fee per person, as opposed to a charter boat, whereby the entire boat is rented. Also called a partyboat in some areas.

Individual Fishing Quota (IFQ) A federal permit under a limited-access system to harvest a quantity of fish, expressed by a unit or units representing a percentage of the total allowable catch of a fishery that may be received or held for exclusive use by a person.

Individual Transferable Quota (ITQ) A type of IFQ that allows for full transferability of the quota-holder's shares.

Interstate Marine Fisheries Commission One of three Congressionally chartered bodies (Atlantic States, Gulf States, and Pacific States) that provide fisheries information, management, and enforcement coordination among regional states.

Juvenile A young fish or other animal that has not reached sexual maturity.

Level of Utilization A comparison of existing fishing effort with that required to achieve long-term potential yield.

Long-term Potential Yield The maximum long-term average catch that can be achieved from a resource.

Magnuson Fishery Conservation and Management Act The federal law that created the regional Councils and is the federal government's basis for fisheries management in the EEZ (now referred to as the Magnuson–Stevens Fishery Conservation and Management Act).

Mariculture The category of aquaculture dealing with the raising of marine species.

Marine Mammals Animals that live in marine waters and breathe air directly. These include whales, porpoises, dolphins, seals, sea lions, walruses, sea otters, and polar bears.

Metric Ton 2204.6 pounds.

Mid-water Species Those fish and invertebrates occupying the water column between the surface and the sea floor.

Model In fisheries science or economics, a description of something that cannot be directly observed. Often a set of equations and data used to make estimates.

Molluscs A group of freshwater or saltwater animals with no skeleton and usually one or two hard shells made of calcium carbonate. Includes the oyster, clam, scallop, mussel, snail, conch, whelk, limpet, squid, and octopus.

National Standards A set of 10 conservation and management standards included in the Magnuson–Stevens Fishery Conservation and Management Act. Each fishery management plan must be consistent with all 10 national standards.

Nursery The part of a fish's or animal's habitat where the young grow up.

Observer An individual hired to observe and record activities and catches (including bycatch) aboard fishing vessels or shoreside processing plants for purposes of managing the target and non-target species.

Open-Access Fishery A fishery in which anyone may participate at any time.

Overfishing Harvesting at a rate greater than that which will meet the management goal. A specific mathematical definition is developed for an individual fishery.

Overutilized Fishing effort in excess of that needed to achieve long-term potential yield.

Partyboat See Head Boat.

Pelagic Fish and animals that live in the open sea, away from the sea bottom.

Population Fish of the same species inhabiting a specific area.

Possession Limit The number and/or size of a species that a person can legally have at any one time. Refers to commercial and recreational fishermen. A possession limit generally does not apply to the wholesale market level and beyond.

Predator A species that feeds on other species (prey).

Predator–Prey Relationship The interaction between a species (predator) that eats another species (prey).

Protected Species Living marine resources protected under the Marine Mammal Protection Act, Endangered Species Act, or Migratory Bird Treaty Act.

Quota The maximum amount of fish that may be legally landed in a time period. It can apply to the entire fishery, to an individual fisherman's share under an individual fishing quota (IFQ) system, or to the size of the fish.

Recreational Fishery Harvesting fish for personal use, fun, and challenge. Recreational fishing generally does not include the sale of catch. The term refers to and includes the fishery resources, fishermen, and businesses providing needed goods and services.

Recruitment A measure of the number of fish that enter a class during some time period, such as the spawning class or fishing-size class.

Relative Abundance An index used to compare the abundance of fish populations from year to year. This does not measure the actual numbers of fish, but shows changes in populations over time.

Selectivity The ability of a type of gear to catch a certain size or kind of fish, compared with its ability to catch other sizes or kinds.

Shellfish General term for crustaceans and molluscs.

Social Impacts The changes in people, families, and communities resulting from a fishery management decision.

Species A group of similar fish that can freely interbreed.

Stakeholder One who is expected to receive economic or social benefits from the conservation and management of living marine resources.

Stock A grouping of fish usually based on genetic relationship, geographic distribution, and movement patterns. Also a managed unit of fish.

Stock Assessment The biological assessment of the status of the resources. This analysis provides the official estimates of stock size, spawning stock size, fishing mortalities, recruitment, and other parameters.

Surimi A processed fish paste, often of Alaska pollock, used for artificial (analog) seafood products, such as shrimp, crab, lobster, and scallop.

Turtle Excluder Device (TED) An implement that has been certified to reduce the likelihood of capturing sea turtles.

Underutilized Fishing effort below the level at which long-term potential yield will be achieved; underutilized species have the potential for large additional harvests.

Yield The production from a fishery in terms of numbers or weight.

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